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THE AGE OF THE EARTH[1]

By Professor GEORG VON HEVESY

OF THE UNIVERSITY OF FREIBURG, NON-RESIDENT LECTURER IN CHEMISTRY AT CORNELL UNIVERSITY UNDER THE GEORGE FISHER BAKER FOUNDATION

BEFORE inaugurating my lectures on this generous foundation established by Mr. George Fisher Baker, I would first of all express my pleasure at having this opportunity to spend a term with my colleagues and the students of this department, which has reached such a high degree of perfection under the able, far-seeing guidance and efficient administration of your genial director, Professor L. M. Dennis. The actuality far exceeds what I had come to expect from the glowing accounts given by my predecessors.

For my introductory lecture I have chosen the problem of the age of the earth. Our earth was born from our sun. The sun, while in the giant-star stage, is supposed to have been broken up by tidal actions induced by a passing star several times more massive than itself. Originally formed in the gaseous state, the earth passed to the liquid state through loss of heat by radiation from its surface, and later into the solid state. The earth's crust and some of its individuals were formed simultaneously, followed at a much later era by the formation of biological individuals. When did the earth's crust solidify? How many years then elapsed before "life" began to develop? These questions are of interest for both the physical and the biological sciences, and an answer will be sought in the following discussion.

Astronomy teaches that the various members of the solar system have originated from the same material. This conclusion is supported by the chemical analysis of meteorites, which not only contain the same elements in approximately the same proportions as in the material of the earth, but also show them in the same isotropic combination. The two nickels of atomic weights 58 and 60 are present in exactly the same ratio in iron meteorites as in terrestrial nickel. The silicon of the stone meteorites contains the three isotopes of atomic weights 28, 29 and 30 in exactly the

[1] Introductory public lecture.

same ratio as does terrestrial silicon. There can be no doubt that the material of the earth separated from the sun's mass and the cooling of the gaseous material led to solidification and the formation of minerals.

The sand-filled hour-glass is the simplest clock. If at any spot on the earth's surface sand were deposited at a fixed rate since the solidification of the earth, then the total amount of sand deposited by this geological hour-glass would indicate the age of the earth, if we could measure the rate of deposition and the volume of the sand. Such geological hour-glasses actually exist. Rivers carry salts to the sea and, knowing the annual volume of salts carried down and the total salt content of the oceans, we can deduce the length of time this process has been in action. This interval of time corresponds to the age of the earth's crust. Even accumulations of sand itself are actually found in nature where rivers have brought sand, mud and sludge down to the sea and deposited them at the river mouth. A knowledge of the total thickness of the sediment and of the annual deposit therefore leads to a knowledge of the date of the beginning of the process. Professor Arthur Holmes, of Durham, to whom we are indebted for numerous important contributions to the determination of the earth's age, makes the following estimates for the maximum thicknesses of the sedimentary strata:

	Meters
Cenozoic Era (modern life forms)	24,000
Mesozoic Era (medieval life forms)	30,000
Paleozoic Era (ancient life forms)	61,000
Precambrian Era	at least 60,000
Total	175,000

We can form a general idea of the rate at which these sediments have been deposited. To take an illustration used by Sir James Jeans in his very stimulating volume "The Universe around Us," since Rameses II reigned in Egypt, over 3,000 years ago, sediment has been deposited at Memphis at the rate of one meter every 1,200 to 1,500 years. With geological strata deposited at an average rate of one meter per 3,000 years, the total 175,000 meters of strata listed above would require over 500 million years for their deposition. At the much slower rate of one foot in 4,000 years,[2] the time would be about 2,100 million years.

As early as 1715 it occurred to the famous astronomer Edmund Halley that from its salt content one might calculate the age of the ocean and hence the age of the earth's crust. In that year he published a paper entitled "A Short Account of the Cause of the Saltness of the Ocean, and of Several Lakes that Emit no Rivers; with a Proposal by Help thereof to Discover the Age of the World." He showed that since the water removed from lakes by evaporation is perfectly fresh, "the saline particles brought in by the rivers remain behind, while the fresh evaporate; and hence it is evident that the salt in the lakes will be continually augmented and the water grow salter and salter." Applying the same principle to the oceans, he wrote: "It is not improbable but that the ocean itself is become salt from the same cause, and we are thereby furnished with an argument for estimating the duration of all things."

In Halley's time the necessary figures for such a calculation were lacking, but 184 years later when the same suggestion was made by Professor Joly, of Dublin, accurate data on the mass of the oceans, their sodium content and its yearly increase were at hand. The oceans contain 1,180,000 billion ($=10^{12}$) tons of water. The sodium content is 1.08 per cent. by weight, so that altogether there are 12,600 billion tons of sodium. Rivers annually contribute 35 million tons of sodium to the sea, and a simple calculation gives the age of the sea = (12,600 billion/35 million) = 360 million years. The salts which the condensing vapors of the magma directly led to the sea by volcanic processes, the amount of salt removed by wind-borne spray, and similar factors are neglected in these calculations. These factors can hardly influence the results to any very appreciable extent; but grave errors may ensue from our tacit assumption that the rate of our geological clock is the same now as it always has been. We assume that the salt additions to the sea and sedimentation proceed to-day at the same rate as yesterday and as ever. These assumptions are not necessarily true; there is definite evidence, indeed, that these regulating processes proceed now more rapidly than the average rate in the past geological ages.

We are now approaching the end of a geological period which is characterized by the formation of hills and rising continents. These conditions are favorable for the transportation of matter to the sea since the river gradients are steeper and the circulation of ground water more thorough. In the long geological ages of the past when the sea flooded the present lands and mountain elevations were consequently appreciably lower, exactly opposite considerations applied. This natural geological change is not the only reason for rejecting the assumption of a regularly running clock. Human activities tend to accelerate these time-keeping processes upon which our calculations depend. Man cultivates the land, cuts off and uproots the forests, and his industry brings large quantities of soil into the rivers. Many

[2] The present rate of subaerial denudation over North America is estimated at 15 cm, or about 6 inches, in 4,000 years.

of the largest and geologically most active rivers such as the Ohio and the Mississippi flow through cultivated and thickly populated districts where formerly forests protected the land from erosion. The sodium gained by the sea in the past must, therefore, have been less than at present, and the age of the sea as estimated from its sodium content must be set correspondingly higher. Similarly, the age as estimated from the sediments must be also increased. The late Professor Barrell even succeeded in showing a definite rhythm in geological processes. He showed conclusively that most regions of sedimentation have been subject to alternate scour and fill, and that the actual thickness ultimately preserved is merely the balance left by these two processes.

Geological methods for determining the age of the earth as thus sketched evidently do not satisfy the most important assumption that the time-indicating processes proceed now at the same rate as they have always done in the past.

The astronomer as well as the geologist is interested in the age of the earth and has also applied his principles towards the solution of the problem.

The fate of the earth is bound up with the fate of the sun. If it were possible to determine the present age and the term of the life of the sun, then the same period is simultaneously the maximum possible life of the earth. The sun loses energy at the rate of 3.3×10^{33} ergs per second, and if we knew the source of this energy, it would be possible to calculate the time required for the sun to reach its present state. Helmholtz and Kelvin believed—in agreement with the state of physical learning in their day—that the contraction of the sun provided its energy. A contraction indicates a segregation of material toward the center and a consequent liberation of potential energy which would be converted into heat. Lord Kelvin calculated that the shrinkage of the sun to its present size could have provided energy for hardly more than about 50 million years of radiation in the past.

If these calculations are applied to the calculation of the age of other stars, it soon becomes apparent that the results obtained are untenable. δ Cephei, one of the variable stars, radiates 700 times as much heat as our sun. According to the above theories, this star should have decreased in radius by 1/300 since 1788 when it was first carefully observed, but the actual contraction is not more than 0.5 per cent. of the calculated value.[3]

In addition to these and other astronomical contradictions, numerous geological arguments oppose so low an age as 50 million years for the sun and the earth. Thus the contraction hypothesis must be rejected. Stellar energy must have some other source.

To-day we know that colossal energy is stored in the nuclei of the atoms, and this knowledge is one of the most important results of our modern study of the transmutation of the elements. It is most natural to assume that this large amount of energy is the source of the radiation from the sun and stars. As the amount of stored-up energy of a star determines its length of life, modern astronomical theories through this nuclear energy just referred to arrive at a possible life-span for the sun several hundredfold that estimated by Kelvin.

The energy stored in the atomic nuclei can be set free in many ways. Radioactive decay, the dissociation of heavier into lighter atoms, sets free a comparatively small quantity of heat, although even this is many times greater than the heat developed by a normal chemical reaction. For example, the heat obtained from the decay of one gram of radium, which requires about 20,000 years for its practical completion, is 3.7×10^9 calories, which is equal to the heat of combustion of 500 kg of coal. Other processes, involving the atomic nuclei, supply yet larger quantities of energy, namely, syntheses of the elements from the hydrogen atom.

The nucleus of the helium atom contains four protons, and consequently the nucleus of the helium atom should be four times as heavy as the hydrogen atom. This is not the case, however, for the helium atom mass is 0.8 per cent. less than that of four hydrogen atoms. The difference is due to the fact that during the formation of the helium nucleus from 4 protons and 2 electrons an enormous quantity of energy is set free and radiated. Now according to the theory of relativity a loss in mass corresponds to a loss of energy, although this is never noticed, as a rule, in ordinary chemical reactions on account of the extremely small mass which corresponds to one erg of energy. One gram of mass corresponds to the absolutely prodigious amount of energy of 10^{20} ergs.[4] The extreme ratio between the units of mass and energy will be more readily understood from the following example.

If 100 carloads of coal were burned to carbon dioxide, then the combustion of this million kilograms of coal would set free a large amount of energy, but the loss of mass due to the release of this huge amount of energy would be equivalent to only about 1 gram. In the processes of the atomic nuclei, however, the

[3] So large a change in its radius should have caused a change in the rate of oscillation of δ Cephei, but this has not been observed. This point is discussed by Sir Arthur Eddington in his illuminating book "Stars and Atoms."

[4] According to the special theory of relativity, the relation between mass and energy is given by $E = c^2 m$, where c is the velocity of light.

quantities of energy involved are so colossal that the resulting changes in mass are no longer negligible.

The difference in mass between one helium atom and four hydrogen atoms together with a number of similar values, thanks to Aston's marvelous experiments, are now known with great precision, and these enable us to calculate the energy set free by the formation of a helium atom from the four protons and in similar atomic reactions. Such syntheses are the sources of extraordinarily huge amounts of energy.[5]

Radioactive disintegration is the transformation of heavier elements into lighter ones, and is a well-studied phenomenon, but very little is known about synthesis, the reverse process.

In the Cavendish Laboratory at Cambridge and in other research institutions like Professor Harkins' Laboratory in Chicago the disruptions of the nuclei of light atoms under bombardment by alpha-particles have been studied. It was found that a minute proportion of the alpha-particles was successful in disrupting the nuclei, and some of the successful particles remained in the nucleus of the bombarded nitrogen atom. The latter lost a proton (mass 1) and gained an alpha-particle (mass 4), the actual increase in mass being 3. The nitrogen atom was thus converted into an isotope of oxygen (atomic number $7-1+2=8$). It is to be presumed that a building up or synthesis of heavier elements from lighter ones takes place on a large scale in some unknown part of the universe.

Radioactive decays and the synthesis of the elements from hydrogen constitute two sources of enormous energy that were unknown to Kelvin and his contemporaries. Furthermore, the sources of energy are not yet exhausted. The mass can even completely disappear and be converted entirely into energy. When a helium nucleus is synthesized from protons and electrons 3×10^{18} ergs of energy are released by the annihilation of only 0.8 per cent. of the mass of hydrogen involved; but if the *total* mass of hydrogen be destroyed the energy set free is 125 times as great.

Thus we recognize three sources of energy which may be responsible for the radiation of the sun and other heavenly bodies, viz., in order of magnitude: radioactive decay of the heavy elements; synthesis of the elements from hydrogen; complete transformation of matter into radiation. The ratio of the wealth of these sources is roughly 1 : 1,000 : 100,000. A uranium sun decaying to uranium lead thus can provide only a thousandth part of the energy supplied by a hydrogen sun transforming itself to helium, and only a hundred thousandth part as much as a sun whose mass is completely transformed to energy. In this way we arrive at very different values for the upper limit of the age of the earth, according to which of these possibilities is employed in our calculations. A uranium sun would have a life-period of only 100 million years; a hydrogen-helium sun would have a life of 10^{11} years, and a mass-energy sun (the third type) of 10^{13} years. The first value is certainly too small, for the earth must be younger than its parent the sun and we shall see that the earth is certainly older than 100 million years. Astrophysics also entirely supports this conclusion. Radioactive change can not be the sole source of the sun's radiation.

There are definite astrophysical arguments against the assumption that the sun's center or the material of the stars contain more than 10 per cent. of hydrogen, and these have been discussed by Eddington in his book on "Stars and Atoms." In the event that the source of the sun's energy is the synthesis of higher elements from hydrogen, the above value for its age must be reduced to 10^{10} or 10,000 million years.

The leading astrophysicists regard the assumption of atomic synthesis from hydrogen as insufficient to explain the astronomical phenomena, and they are inclined to the view that the aging of a star consists, to a large extent, in the annihilation of its original mass and its transformation into energy. The simultaneous destruction of 10^{3} protons and electrons per gram of the sun's material per second would suffice to account for the loss of energy by radiation and would secure a continuation of the sun's radiation for 10,000 million years.

It is, perhaps, essential to point out here that just as Kelvin's calculations were vitiated by the less complete state of scientific knowledge at that time, so the same fate can overtake our present calculations. Science is compelled, however, to base its concepts on the contemporary state of knowledge, and nothing makes greater demands on the intuitive and critical faculties of the scientist than the estimation of how far the possible explanations of a phenomenon are exhausted, even when possible future developments are considered.

Nevertheless, and bearing this possible fate fully in mind, we now consider that the knowledge acquired from the study of atomic transformations not only constitutes one of the greatest advances of science but also very probably exhausts the possible sources of the sun's energy.

Geological methods give a lower limit to the possible age of the earth, while astrophysical methods supply an upper limit. The geological clock runs too slowly and the astrophysical too fast. One of the many beautiful achievements of radioactivity is that

[5] The accurate value, as determined by Aston, for the loss of weight when helium is synthesized from hydrogen is 0.00724 per gram of hydrogen.

it has provided us with the necessary magic clock whose accuracy and reliability leave nothing to be desired, and—for us the most important specification—whose rate has remained constant since the solidification of the earth's crust.

Single atoms of uranium and other radioactive substances explode. The number of particles exploding and decaying in unit time is strictly proportional to the number present. For instance, from 10^{15} uranium atoms (4×10^{-7} gm), 1,000 atoms decompose in 5 days; and from 10^{14} atoms there decompose 100 in the same time.

Uranium decay is the desired strictly uniform process whose velocity has remained unchanged throughout geological time, for it is the nucleus which is involved in the decay, and nuclear processes proceed independent of temperature, pressure and other external conditions. Therefore, there is absolutely no reason to believe that the process has gone forward at any different rate than at present at any period in the earth's history. The study of radioactivity with its inexhaustible applications has provided further proof that uranium and other radioactive substances have always decomposed in the past with the same velocity as at present. The decay of a uranium atom is always accompanied by the radiation of an alpha-particle. These alpha-particles, which leave the atom with a velocity of 8,800 miles per second (or about one twentieth of the velocity of light), can travel a certain distance or work on a photographic plate, color mica, glass and other substances within a certain fixed limit from their place of origin.

Beyond this distance, called the range, which in air is about 2.8 cm and in mica about 0.013 mm, the velocity is so small that the alpha-particles are powerless. In nature certain micas such as biotite and muscovite inclose minute uranium-containing crystals. The alpha-particles from these inclosed uranium atoms, in the course of geological ages, have evidently colored the mica over a quite definite area. Some decomposition products of uranium also emit alpha-particles, but these have a different velocity and a correspondingly different range so as to form a ring of different diameter in the mica. The sections of these colored circular areas exhibit the property of pleochroism under polarized light and for this reason were called "pleochroic halos." The diameters of these halos are closely related to the velocity of the decomposition of the radioactive atom from which the alpha-particles originate, as has been experimentally demonstrated; therefore, a change in the rate of decomposition of the radioactive substances during geological time would correspond to an alteration in the diameters of the halos. The halos corresponding to the various radioactive substances have in every case the same diameter, from which it can be concluded that the rate of decay has remained the same throughout the ages. Hence the decay of uranium provides us with a process going on at a strictly uniform rate. To use this rate of uranium decay as a measure of time, however, it is necessary to know two facts: (1) the total quantity of uranium that has decayed in some mineral since the solidification of the earth, and (2) the rate of that decay.

(1) One helium atom originates from the decay of each uranium atom. This helium collects in the uranium-containing rocks and its volume gives the number of uranium atoms that have decomposed since the formation of the rock. (2) The production of 1 cubic centimeter of helium from 1 gram of uranium requires 9 million years. A knowledge of the uranium and the helium content of a rock gives, therefore, its age. According to this method the age of the rocks has been computed to be 570 million years. Although the rocks store a large part of the helium which is produced in them, a small portion gradually escapes in course of time so that the values obtained by this method give only a lower limit for the age of the earth. Fortunately in addition to the helium accumulated in the rocks we may also measure another and this time a solid product which can not escape, namely, lead. Uranium decay leads also to the production of lead, and we need only determine the lead content of the uranium minerals in order to be able to calculate what proportion of the uranium has decomposed since the mineral was formed. The following table shows the rate at which uranium decays and uranium lead is formed:

	Initially:		1 gm uranium	No lead
After	100 million years	.....	0.985 "	0.013 gm lead
"	1,000 " "	.....	0.865 "	0.118 " "
"	2,000 " "	.....	0.747 "	0.219 " "
"	3,000 " "	.....	0.646 "	0.306 " "

These figures refer solely to the chief quantity of uranium, namely, uranium I, which amounts approximately to 97 per cent. The lead which has originated from uranium need not be confused with any accessory lead because uranium-lead has a lower atomic weight (206) than either ordinary lead (208) or actinium-lead (207).

When this lead method is applied to a great number of uranium-containing minerals we obtain the following ages of the geological eras:[6]

[6] Holmes and Lawson calculated these ages from the uranium, thorium and lead content of minerals using their approximate formula:

Geological age	Age in years
Late Oligocene	37 million years
Permo-carboniferous	204 " "
Late Precambrian	587 " "
Middle Precambrian	987–1087 " "
Lower Precambrian	1257 " "

The lead method leads therefore to the result that the Precambrian minerals were in existence even 1,260 million years ago, and therefore the solidification of the earth's crust must have already taken place, perhaps about 1,400 million years ago.

The lead method has proved to be of great importance because its application enables us to determine not only the age of the oldest minerals but also the lower limit of the age of the earth's material and consequently of the chemical elements. The transformation of uranium into lead had already progressed to a certain point while the earth's material was still gaseous. The lead (206) so produced did not remain isolated as such, however; it had opportunity at that stage to mix with the thorium lead (208) from thorium decay and as a result common lead (atomic weight 207) was produced. Hence approximately half of our common lead was formed from uranium before the earth's materials had solidified. The ratio of all the uranium to about half of the common lead (plus the uranium lead) present in the whole earth's material must give the age of the earth's material. To a certain extent we can regard the whole earth as a colossal uranium- and lead-containing mineral. From this standpoint we consider not only the lead now existing as pure uranium lead or thorium lead, but also that other lead which *was* produced as uranium, thorium or actinium lead but has ceased to exist as such on account of mixture with thorium lead in the gas-liquid earth. Such a mixing of practically chemically identical elements, the so-called isotopes, was a common occurrence and must be the explanation for the fact that, for example, chlorine always has the same atomic weight. In whatever form chlorine occurs in nature there is always the same ratio between its two isotopes Cl (35) and Cl (37). The lead which has been produced in uranium minerals has had no such opportunity to mix with thorium lead, and consequently it has remained fixed as uranium-lead. H. N. Russell first drew attention to the fact that by such a method as the above the upper limit of the age of the earth could be calculated, but at that time it had not been proved that ordinary lead is a mixture of uranium-lead and thorium-lead. Since then Aston has succeeded by means of his mass spectrograph in showing that normal lead is chiefly such a mixture. These outlined considerations give about 3,000 million years as the upper limit of the age of the minerals and the lower limit of the age of the earth's *material*. During this huge period, it is only the few radioactive elements, decaying according to accurately known laws, that have altered; the other elements which build up the earth's constituents have undergone no change.

Formerly one was inclined to make no distinction between the radioactive and non-radioactive elements, and to believe that elements of the latter class were also transformed, although extremely slowly. Aston's beautiful experiments have shown, however, that this is not so. The heavy radioactive elements decay with an energy loss, whereas in the synthesis of the lighter elements from protons or alpha-particles energy is set free. Thus there is a basic difference between the radioactive and the non-radioactive lighter elements.

All the minerals and rocks which have been subjected to tests by the helium and lead methods have been taken from the earth's crust, since samples from the center of the earth are not obtainable. When the geochemist desires to know details of the composition of the interior of the earth, he turns to the meteorites and makes the assumption that iron meteorites correspond to the iron core of the earth and the stone meteorites to the more or less silicate layer. On account of experimental difficulties, only the helium method has hitherto been applied to the determination of the age of meteorites. The disadvantage of this method, that the helium can escape from the sample in course of time, is here without significance since the iron meteorites even when heated to a red heat lose no trace of helium. In recent years my predecessor in this lectureship, Professor Paneth, has developed the methods for helium determination to such an extent that one can measure 10^{-7} cubic centimeters of helium, and he has carried out determinations of the ages of meteorites. He has found for the iron meteorites a maximum age of 2,600 million years. This result lends additional appreciable support to the theory that the meteorites and the earth were formed from the same stellar material.

We can follow the fate of the earth's materials back for about 3,000 million years and show that, except for the few radioactive substances, the elements have undergone no change in the course of these years. How and to what extent the individual elements have appeared and disappeared in the span of about 8 million million years between the creation

$$\text{Age} = \frac{z}{x + 0.38\,y} \times 7{,}400 \times 10^6 \text{ years.}$$

They denoted by z the grams of lead present in the mineral, by x those of uranium and by y the grams of thorium. As thorium is usually associated with uranium, the thorium present must be, in practically every case, taken into account.

of the sun and the creation of the earth remains, however, hidden from us. Astronomers estimate the sun's age as about 8 million million years.

The study of radioactivity has led us to the above conclusions. Scientific research attempts to discover and to explain the connections of the natural phenomena. The most fascinating feature of such research is that the experimenter never knows whither the developments may lead. When Bequerel discovered radioactive rays, he had no idea that his discovery would lead to an efficient method for determining the age of the earth. The action of X-rays caused a green fluorescence of the glass walls of his tubes and Bequerel wished to determine whether all fluorescing substances sent out X-rays. Thus he discovered the action of uranium on a photographic plate and hence the radioactive rays. Continuing Becquerel's work, Pierre and Marie Curie were led to study the activity of uranium-containing minerals and discovered in pitchblende the presence of an element radiating much more strongly than uranium, namely, radium. The radioactive rays and radium were indeed epoch-making discoveries; but the most important contribution to the science of radioactivity was made by Rutherford and Soddy when they recognized that radioactive radiation was merely a subsidiary phenomenon accompanying the transformation of uranium and the other radioactive elements, and that it indicated a *disintegration of the atom*. They pointed out that the disintegration products must be present in uranium minerals and accumulate in the mineral in the course of time. Boltwood, who did so much for the early development of radiochemistry, studied a series of uranium minerals, and the constant ratio of uranium to lead struck him as remarkable. He concluded that lead was the end-product of the uranium disintegration and was the first to suggest that the uranium-lead ratio could be employed for the determination of the age of the earth. Simultaneously, the present Lord Rayleigh showed how the accumulation of helium in the uranium minerals furnished a method of determining their age. Experimental and theoretical researches by many workers were necessary in order to extend especially the lead method and to lead to the well-established numerical values here given.

The age of the earth according to ordinary time standards is enormous, but when compared with the age of some stars our earth is extraordinarily young. Three different astronomical methods can be applied to the calculation of the age of the stars, and all three astronomical clocks show the same time, 5 to 10 million million years. If the age of a human being is 1 second, of the human race 6 hours, then the lower limit of the age of the earth is one year, and the age of the stars is 5,000 years.

THE ORIGIN OF SOUTH AFRICAN ALLUVIAL DIAMONDS[1]

By Dr. GEORGE FREDERICK KUNZ

NEW YORK

ONE of the most important contributions of recent years to the technical literature on the diamond was the comprehensive and masterly treatise on "Diamond-Bearing Alluvial Gravels of the Union of South Africa," presented before the Empire Mining and Metallurgical Congress in Johannesburg in March, 1930. The author, Alpheus F. Williams, a graduate of the University of California and Lehigh University and general manager of the De Beers Consolidated Mines, is the son of the late Gardner F. Williams, the great organizing engineer who, after Cecil Rhodes had unified the mines, did much to bring about the establishment of the methods of control of the native labor that prevented the great amount of pilfering that had previously not only absorbed much of the profits of the mines, but had also damaged the market for the legitimate stones by the sale of the illicit stones. Mr. Williams's paper includes in its 169 pages some 52,000 words of text, 6 maps of the districts under discussion, 38 illustrations and an appendix listing the weight, name of finder and the location and date of discovery of 66 diamonds of 100 carats or more that have been found in the South African alluvial gravels. These 66 stones range in weight from 100 carats to 416 carats, and total 11,324 carats.

Ever since their discovery, the origin of the alluvial diamonds and the methods by which they were transported from their source to their final location have been subjects for speculation and debate. The first alluvial diamond in South Africa was found in the early spring of 1867 near the junction of the Orange and the Vaal Rivers among the bright pebbles picked up by a farmer's children. How many others had been picked up in this way and then lost or discarded no one will ever know, but fortunately this particular pebble caught the mother's eye, because of its bright-

[1] A review and discussion of the paper of Alpheus F. Williams on "Diamond-bearing Alluvial Gravels of South Africa."

ness, and she brought it to the attention of a neighbor, who became interested, and out of curiosity and in the face of considerable difficulty tried to find out what it was and its value. Naturally, gem experts were not plentiful in this remote district, and though no definite information was at first obtained, the prevailing opinion was that the stone was a topaz. However, when one of these amateur mineralogists discovered that the crystal would scratch glass, he expressed the opinion that it might be a diamond. The leading topaz advocate took exception to this, and the ensuing argument resulted in a wager of a new hat. This brought things to a point where the uncertainty must be settled, and the stone was submitted to a mineralogist resident at Grahamstown, who pronounced it a diamond of 21¼ carats, and valued it at £500. And thus, through a series of fortuitous circumstances, the diamond industry of South Africa was brought into existence.

Some ten months later a second stone turned up, more than thirty miles lower down the Orange River. During 1868 several more were picked up by natives along the Vaal River. After this beginning, for four years the alluvial diamond industry of the world centered around the gravels of the Vaal River basin, rapidly supplanting India and Brazil and the other less important producing districts. Up to this time, alluvial deposits of this kind were the sole source of supply, and the only diamonds known were "river" stones.

Late in 1870 and early in 1871 diamonds were discovered in "dry" diggings in several localities in the neighborhood of what is now Kimberley. In each case these deposits proved to be very restricted in area, of rounded or elliptical shape, not more than a few hundred feet in dimensions and of considerable depth, instead of broad and shallow as were the river diggings. Furthermore, these dry diggings, after working to a considerable depth, changed in character, and the friable "yellow ground" of the top layers gradually gave way to a soft blue green called "blue ground," and for the first time in history diamonds were found in their original matrix, of yellow, soft blue, and then hard blue.

The question immediately arose as to the relation between the river stones and the dry stones. Were they of the same or similar origin, or were the sources entirely different and independent?

The fact that the pipes of blue ground were some twenty miles from the nearest river deposits, with no diamonds in the gravels in the intervening areas, seemed to indicate a separate origin, but this was not necessarily conclusive. Another argument that carried even more weight was the fact that the characteristics of the river stones were entirely different from those of the mine stones, but later other pipes were discovered, the diamonds from which showed the same characteristics as certain of the river stones, indicating that while the river stones had not originated in the first known pipes, some of them may have come from others, and some from pipes never discovered, or from the top levels of pipes which have been discovered but are not now diamond-bearing. It is well established that the pipes are richer in diamonds in their upper levels than in the lower ones, and even though some lower levels now known are not diamondiferous, the upper levels that have been eroded away during past ages might still have supplied enormous quantities of diamonds to the gravels formed and washed away during the process of erosion. It is not even necessary to assume any great amount of erosion and lowering of the general level of the country surrounding the pipes. Kimberlite is generally accepted as being of volcanic origin. If considerable amounts of kimberlite emerged from the pipes and covered the surrounding territory, as is not infrequent in volcanic outpourings, even more kimberlite might have been raised to the surface than was left in the pipe, and it might also have been richer in diamonds than that remaining in the pipe, or less so.

The quantities of material available in the diamond pipes centered the main working of the industry on the mine product, and the output of the alluvial deposits soon took a secondary place. Although the extent of the alluvials was widened from time to time by new discoveries, no important developments were made until 1908, when diamonds were found in the sands along the coast of South West Africa, then a German colony. In 1911 rich discoveries were made in western Transvaal, and the territory worked gradually increased, but without further outstanding developments until the discovery of the Lichtenburg fields early in 1926. Late in the same year the coastal territory again came into prominence with the discovery of the phenomenal deposits in Namaqualand, at the mouth of the Orange River. As a result of these last two discoveries the alluvial output of South Africa in 1927 was over 49 per cent. of the total output by weight, and over 50 per cent. of the total value, while in 1928 it was over 48 per cent. by weight and over 66 per cent. by value; previous to this, these proportions had for many years averaged about 10 per cent. by weight and 22 per cent. by value. These enormous increases in the alluvial output naturally created a proportionate increase in interest in the character and origin of the alluvial stones, particularly those of these two exceptional districts.

After an exhaustive review of the contributing agencies, such as weathering and erosion, and of normal drainage and flood drainage in the transportation

of weathered material, Mr. Williams expresses the opinion that "most of the diamonds found in the gravels of South Africa originally came from the disintegration of kimberlite deposits, but that this origin may not apply to all the diamond-bearing gravels in other parts of Africa, or in other parts of the world."

Taking into consideration the number of known diamond-bearing pipes and the possibility of others as yet unknown, the diamond content of the kimberlite of the various mines and particularly the fact that the diamond content of the pipes invariably decreases with depth, the amounts of kimberlite eroded in past ages from above the present ground level must have liberated enormous quantities of diamonds. In the Premier mine alone, operations to date have produced more than a *ton* of diamonds from each hundred feet of depth of the pipe; and there is geological and paleontological evidence indicating that the original pipes penetrated several thousand feet of strata that have since been eroded away.

Weathering and erosion over long periods of time liberated the diamonds from their matrix in these pipes, and the products of erosion were carried off by the streams draining the area, slowly during periods of ordinary rainfall and more rapidly in flood periods. As erosion proceeded more rapidly in some sections than others, the topography of the country was changed, and partly due to this and partly due to the deposition of erosion products in those portions of the streams where the current was less swift, the beds of many streams were gradually shifted, and the boundaries of the various drainage areas were changed. These changes were also affected by any changes of level due to earth-lift or depression that took place during this time. Particularly in those portions of the drainage area where active silt deposition was taking place, heavy floods were liable to make considerable changes in the stream path. In this way gravels and silt that had originally been deposited in one place were transported to other areas. Thus the eroded material was gradually shifted from place to place; some portions were left at the original location, while other portions were flushed to new locations at various periods; the remainder finally reached the sea, to be distributed up and down the coast by ocean currents and washed up on the shore by wave action.

The normal rate of transportation of solid material in moving water is dependent on the velocity of the water, the size of the particle and its specific gravity. The rate of progress of finely divided, suspended silt is equal to the speed of the water carrying it, but when the size of the particles of solid is such that it can no longer remain in suspension, movement progresses only by washing and rolling along the bed of the stream. Under such conditions the rate of progress depends on a number of conditions. Fine material moves faster than coarse; smooth, rounded stones move faster than rough or flat ones; material of high specific gravity, like the diamond, would tend to sink below ordinary gravel and sand, and would move slower, unless the current were sufficiently turbulent to wash everything along together. In addition to these variables there are others that are imposed by the character of the country through which the diamonds are being transported. Clefts and fissures in the rock along the stream bed catch stones and hold them, unless the increased turbulence of high water or the gradual disintegration and erosion of the rock sets them free again. In limestone and dolomitic areas, pot-holes of all sizes form temporary or permanent traps. These and many other hazards make the diamond's journey to the sea a long and tedious one, and only a fraction of them eventually reach the final destination. Many remain along the way, trapped in a rock crevice, a gravel bar or a pot-hole, or washed out on a flood plain. Others, particularly the small and faulty stones, perish on the way, unable to stand the cruel grinding and battering that serves only to put a nice polish on a larger and more perfect stone, or possibly slightly round its sharp edges and corners.

Although the edges and faces of many alluvial stones are as sharp and smooth as of those recovered directly from kimberlite, in general the alluvial stone shows the effects of abrasion in chipped and rounded edges and corners, and in faces pitted and marred by percussion marks. The degree to which the stone shows these effects is usually considered a measure of the distance through which it has been transported, but this is not always true. The wear on a diamond is not necessarily a measure of the distance it has traveled, but rather of the time occupied by the journey and of the amount of punishment to which it has been subjected (in pot-holes, etc.) during the transportation. In a pot-hole where the percentage of diamonds in the gravel was high, abrasion of diamond on diamond might give considerable wear, where with only a small percentage of diamonds the wear from the gravel alone would be small and might not even be apparent.

THE LICHTENBURG DIAMONDS

Although the main production of alluvial diamonds in South Africa continued for many years to come from the immediate vicinity of the original discovery, near Hopetown on the Orange River, other producing districts of less importance were gradually added, some at considerable distances. Shortly after the discovery of the kimberlite pipes, the mining industry was consolidated into a few large companies, but in

contrast with this, the alluvial industry remained unorganized and in the hands of thousands of individual diggers. Production increased slowly, and it was not until 1913 that it passed 200,000 carats. During the war years production declined and did not again equal the prewar output until 1919. From 1919 to 1925 production fluctuated between 200,000 and 300,000 carats annually. Early in 1926 the Lichtenburg discoveries increased the output rapidly to 800,000 carats for the year, and to the high-water mark of 2,300,000 carats in 1927, after which there was a decrease.

In general, alluvial stones grade better than the average run of mine stones, both in size and quality. This is due to the rough treatment to which they have been subjected during their transportation, which broke up the faulty stones and washed away the smaller sizes. In this respect the Lichtenburg diamonds differ from those of other fields, for they include many small, broken and faulty stones. This is well shown by the average value of the stones recovered from various areas. While the average value per carat of stones from the Cape Province and Orange Free State runs from 100*s.* to 250*s.*, the average for the Lichtenburg stones is about 50*s.* per carat. This may be accounted for by the peculiar conditions under which the gravels were deposited. The Lichtenburg area is dolomitic in character, and the gravels were deposited in a network of gullies and pot-holes in the dolomite in such a way that they were largely protected from further transportation. Because of the number and size of the gullies and pot-holes, their contents were not subjected to the same amount of churning and washing as would be the case in the ordinary small pot-hole, and as a result most of the contents remained intact, while in a small pot-hole subjected to violent churning by the river current, the smaller stones and the broken fragments of faulty stones would be washed away.

From the various facts that have been established concerning the alluvial gravel deposits in the western Transvaal, Mr. Williams has constructed a theory as to what occurred before and during the transportation of the diamonds and their associated gravels into the areas in which they are now found.

The head waters of the Orange and Vaal Rivers apparently extended well into the territory that is now drained northward into the Limpopo River. After erosion had proceeded for a sufficient time to produce an extended peneplain, earth movements tilted the strata, and erosion again moved large quantities of the material southward. It was at this time that the diamond-bearing gravels were first transported into the areas in which they are now found. By the time the rivers reached the dolomitic area they must have been of considerable size, and in the early stages must have passed through this country as torrents, carrying all their eroded material with them and depositing it in lower areas where the velocity of the stream was less. The gravels as they are now found rest on a bed originally cut by a river running under quite different conditions from those existing at the time of the deposition of the gravels. The change from a torrent to a moderately slow river must have occurred gradually, because the change depended on the general erosion of the country at the same time. It was at the end of this latter period that the bedrock of the river was so altered as to be able to trap a large amount of diamond-bearing gravel in its gullies and pot-holes.

Whether the gravels transported through the dolomitic area during the earlier period carried diamonds can not be definitely established, but there seems no reason to the contrary, and the assumption that they did would explain many of the problems involving the variation in type, size, quality and quantity of the stones found further down the river system, as well as at the mouth of the river.

The transportation of material by this river system toward the south and southwest continued until some change, either in earth-movement or the encroachment of the erosion of the rivers to the north, altered the direction of the flow and turned the drainage northward.

From many pages of evidence collected by himself and quoted from other authorities at too great length to include here, Mr. Williams has evolved the above explanation and reached the conclusion that the diamonds found in the Lichtenburg area came originally from gravel deposits or igneous formations located somewhere in northern Transvaal, or even to the north of this country. This, however, does not necessarily mean that there exist to-day in that section any diamond-bearing formations of commercial importance. The gravels as they are found to-day are the concentration product of erosion acting over many geological ages, and the original source may have been of very low grade.

THE NAMAQUALAND DIAMONDS

In 1908 diamonds were discovered along the coast of German Southwest Africa, north of the mouth of the Orange River, in such quantities that a year later production was at the rate of half a million carats a year, and five years later was three times that amount. This was the first important discovery of alluvial diamonds at any appreciable distance from the original discovery near Hopetown. Late in 1926 Merensky and his coworkers discovered the phenomenal coastal deposits of Namaqualand, just south of the mouth of the Orange River—the most outstanding dis-

covery in diamond history, and, following the Lichtenburg discovery made a few months earlier, completing the most dramatic year the industry had ever experienced. Although several thousand carats were recovered in prospecting operations in 1926 and 1927, no active production from this new field was undertaken until 1928, when the output for the year exceeded 900,000 carats, valued at over £7,600,000.

The problem of the origin of the Namaqualand diamonds to a considerable extent begins where that of the Lichtenburg area ends.

Shortly after the discovery of the coastal diamonds of Southwest Africa, a theory was proposed that they had been washed up on the shore from a disintegrating submarine pipe somewhere off the coast. In the light of later information, particularly after the Namaqualand discoveries, this theory was abandoned in favor of one to the effect that these diamonds had a source the same as or similar to the inland alluvial deposits, differing only in that while the inland deposits had been dropped at various points along their courses, the coastal deposits were formed by the material that the rivers had succeeded in carrying clear to the mouth, later to be distributed up and down the coast by ocean currents and washed up on the shore by wave action. The remaining difficulty was to determine whether this transportation had been effected by the Orange River system alone or its ancient equivalent, or whether its work had been supplemented by the Kamma, Buffels and Groen Rivers, thus forming several sources of distribution instead of a single one. As has already been pointed out, there is evidence that in past geological times the drainage basin of the Orange River system extended well beyond its present limits, and while there is less actual evidence to support it, it is not unreasonable to assume that the mouth of the river has not always been where it is at present. This too might furnish more than one source of distribution. The diamond content of the marine terraces adjacent to the present mouth, however, seems to indicate that for a very long period the mouth could not have been many miles distant from its present position.

After careful consideration of all available evidence, Mr. Williams arrived at the conclusion that the coastal diamonds of both Namaqualand and Southwest Africa originated in the igneous rocks of the drainage basin of the Orange River, or its ancient equivalent; that after liberation by erosion they were transported by the river to the sea, and that after being deposited in the sea they were distributed up and down the coast by ocean currents and washed up on the shore line by wave action. During and subsequent to the time of the deposition of the diamonds along the shore there was a general coastal uplift, which resulted in the formation of a marine terrace. Apparently the Merensky deposit was the oldest of the marine terraces, only a portion of which remains. A very rich terrace of considerable extent was formed by the original deposition, but much of this was later washed away by successive floods, leaving only the fragments, of which the Merensky deposit was the chief one. The diamonds and gravel washed away from the original terrace were deposited in new areas along the coastal belt, or were again washed out to sea, where some may have been lost, and the remainder was again washed up along the shore line, and by subsequent earth-lift became a terrace of later age, although much of the material in it was derived from the original terrace. Mingled with the older material was the newer material brought down by the flood that washed out the original terrace. Mr. Williams thinks that there have been at least three and possibly four such periods, during which diamonds were concentrated along the shore line and later elevated into marine terraces. Although the various uplifts were apparently quite uniform in their extent, the erosion which partially destroyed the terraces was decidedly erratic in its action, leaving the terrace almost unaffected at one point but completely destroyed at another.

This is the story, as traced by Mr. Williams, that accounts for the formation of the Merensky terrace, which with its adjacent gravels had yielded, up to the beginning of 1930, more than a million and a quarter carats of as fine diamonds as the world has ever seen, valued at more than £10,000,000, as well as the other, though less richly seeded terraces up and down the coast of Southwest Africa and Namaqualand for a distance of several hundred miles.

The reviewer states that in the transportation of the diamonds from the interior to the sea, the conditions at the mouth of the river form one of the most important features, and in this connection he desires to emphasize certain factors that have an important bearing on the question. When the fresh water of a river meets the salt water of the sea, the salt causes the deposition of the silt suspended in the fresh water, and this gradually builds up a sand bar at the mouth of the river, which serves as a dam. This action is a familiar one in all large rivers carrying a large amount of suspended material, such as the Mississippi and the Hudson. During the seasons of ordinary flow in the Orange River the transportation of the gravel with its associated heavier minerals, such as diamond, garnet and ilmenite, was slow, and such as did reach the mouth from the upper river accumulated behind the bar. In seasons of moderately high water the transportation was more rapid, but the bar at the mouth of the river held back the transported material from the

sea. In time of heavy flood, when the rush of water was sufficient to wash out the sand bar, the river flow carried down not only the additional amount of material for which the rapid current furnished the necessary carrying power, but also flushed out more or less gravel from the gravel bars that had formed along its course, as well as that which had accumulated behind the sand bar at the mouth, and carried it all out to sea. The sand bar was also subject to attack from the ocean side, by heavy storms at sea; these storms not only furnished the means of destroying the sand bar and for the time being opening the mouth of the river for the free transportation into the sea of the gravel and diamonds accumulated behind the bar, but also served to distribute the diamond-bearing gravel along the coast, to the northward in the case of a storm from the south or southwest, and to the southward in the case of a storm from the north or northwest. In this way the diamonds were carried many miles both to the north and the south of the mouth of the river. The carrying capacity of the storm water for the diamonds was increased by the fact that the turbulent water along the shore line was heavily charged with suspended sand, and the buoyancy of the diamonds in this sand-water was proportionately increased, because of its higher specific gravity.

Once deposited in the sea, the diamonds and gravel, under the influence of storms, ocean currents and wave action, were not only distributed up and down the coast and washed up on the shore line, but the constant riffling action of the waves supplied a concentrating action, with the result that the larger stones were deposited close to the river mouth, while the smaller ones were carried farther up and down the coast.

SCIENTIFIC EVENTS

ANTHROPOLOGISTS AT THE WELLCOME MUSEUM

The British Medical Journal reports that a reception for the members of the Royal Anthropological Institute and other bodies interested particularly in African races and culture was held at the Wellcome Historical Medical Museum on October 10, Dr. Henry S. Wellcome, the museum's founder and director, acting as host. After making a tour of the museum, which includes an exposition of the healing arts as practised among primitive peoples, the visitors were addressed by Lord Lugard, formerly Governor-General of Nigeria, and now British member of the Permanent Mandates Commission of the League of Nations. The interest which had been shown in the welfare of subject races during the past few years, said Lord Lugard, was one of the most remarkable phenomena of the twentieth century, but in reality it had been growing ever since the abolition of the oversea slave trade. In his own acquaintance with the lawless savage Lord Lugard had found that in fact tribal organization exercised an effective discipline, and created a strong patriotism for the local community and an unswerving loyalty to the chief. Tribalism had its own code of civil and criminal law, and had evolved among other things a system of land tenure. He emphasized the need for that first task of the anthropologist, the study of existing institutions among primitive peoples. To that end Dr. Wellcome's extremely interesting museum, illustrating the practice of medicine throughout the world from the earliest ages, makes a great contribution. Lord Lugard linked it with the ethnological museum in the Lateran Palace at Rome, which showed in contrast the earlier conditions of primitive savagery and the achievements of to-day, thanks to missionary effort on various lines, including educational and medical. Such collections conferred great benefits on both the white man and the black, and would assist in solving the problem of race relations in the future. Professor J. L. Myres, president of the Royal Anthropological Institute, also expressed to Dr. Wellcome the feelings of gratitude with which anthropologists regarded one of the most stimulating museums in the country. It was a museum where the objects themselves were of extraordinary interest; but what gave them their peculiar value was that they were all eloquent in their selection, arrangement and description of the continuity and development of one of the noblest of applied sciences that mankind had at its disposal. Other speeches were made by Dr. C. S. Myers, director of the National Institute of Industrial Psychology; Dr. H. J. E. Peake, vice-president of the Royal Anthropological Institute, and Mr. T. A. Joyce, deputy keeper of the department of ethnography in the British Museum. Dr. Wellcome, in a few sentences in reply, explained how, soon after he began collecting, the idea of assisting research workers and students took possession of his mind, and he gradually formed a museum which visualized, as a museum should do, within its particular sphere, the failures and mistakes as well as the successes of the past.

WILD LIFE IN CALIFORNIA

IN an effort to preserve accurate records of the distribution of wild life in the Lassen Park area of California before further changes incident to its conversion into a public domain take place, the University of California Museum of Vertebrate Zoology has published a report extending to 595 pages.

This report, which represents almost two years of observation in the field by 12 members of the staff of the museum, is based upon a total of 3,592 specimens collected for study, including 496 reptiles and amphibians, 1,601 mammals, 1,453 birds, and 34 sets of birds' eggs, for the most part with nests. In drafting the report consideration has been given to 387 different kinds of vertebrate animals, from meadow mice, water dogs and humming birds, to bear, beaver and the California condor.

The strip of territory included in the survey is 24 miles wide and 124 miles long, or an area of 2,976 square miles, ranging from an altitude of 300 feet or less in the Sacramento Valley floor, to the great basin platform at an altitude of 5,300 feet, and the top of Mt. Lassen at 10,451 feet. The north line of the area runs roughly from a point 12 miles north of Red Bluff on the west side of the Sacramento River, to a point about seven miles north of Red Rock Post Office, just inside the California-Nevada boundary. The south line runs roughly from Tehama on the Sacramento River, to the California boundary about where Smoke Creek crosses the boundary.

During recent years the University of California, in the development of a faunal survey of the Pacific Coast and of California in particular, has made intensive studies of six other prescribed areas of the state.

Support for the study as well as the first field observations in the area came from a friend of the university, Miss Annie M. Alexander. The report was edited by Professor Joseph Grinnell, curator of the Museum of Vertebrate Zoology; Joseph Dixon, economic mammalogist, and J. M. Linsdale, research associate. Other collectors who added to the field material were Adrey E. Borell, Hilda W. Grinnell, Richard Hunt, Louise Kellogg, Chester C. Lamb, Tracy I. Storer, Harry S. Swarth, Walter P. Taylor and Leo K. Wilson.

The objectives kept in mind during the survey of the area were: what kinds of land vertebrates are present, the frequency of observed occurrence and relative abundance of these kinds, the local or habitat distribution of each kind, the factors which determine the presence and habitat distribution of each kind, the annual cycle of activity of each kind in the section, and a method of analyzing vertebrate animal communities and successions.

Explanation is made that the work has been published by the University Press, not as a popular guide, but as a scientific record of the wild life of the area for the use of naturalists and students.

REGIONAL REORGANIZATION OF THE U. S. BIOLOGICAL SURVEY

FIELD workers of the U. S. Biological Survey engaged in cooperative campaigns for the control of injurious rodents and predatory animals will be grouped, effective on January 1, 1931, in four regions, according to an announcement made on November 11 by Dr. Paul G. Redington, chief of the bureau. The Secretary of Agriculture has approved this regional plan of organization.

The grouping, with each region in charge of a supervisor, will coordinate more closely the work of the bureau throughout the country. Each supervisor will be in contact with the state leaders in his region, and also with the administrative heads of the bureau in Washington.

The new regional supervisors are men who have had wide experience in the wild animal control work of the bureau. James Silver, with headquarters at Washington, D. C., will supervise Region No. 1, comprising all states east of the Mississippi River, including all of Louisiana. Mr. Silver is at present leader of the bureau's eastern rodent control district, which occupies approximately the same area as the new region.

Region No. 2 will be supervised by Leo L. Laythe, with headquarters at Denver, Colorado, and will cover the states of Montana, Wyoming, South Dakota, Colorado and Utah. Mr. Laythe is at present state leader of predatory animal and rodent control for the Biological Survey in Colorado.

Region No. 3, with headquarters at Portland, Oregon, will include the states of Washington, Oregon, Idaho, Nevada and California. Ira N. Gabrielson, at present state leader of rodent control for the Biological Service in Oregon, is the new supervisor.

Don A. Gilchrist, leader of predatory animal and rodent control for Arizona, will be in charge of Region No. 4, comprising the states of Arizona, New Mexico, Oklahoma, Arkansas and Texas with headquarters at Phoenix, Ariz.

The new regional supervisors will each spend some time in Washington before the first of the year to acquaint themselves with the policies of the bureau that will be effective when the change is made.

THE SECOND INTERNATIONAL CONGRESS FOR SEX RESEARCH

THE house of the British Medical Association in Tavistock Square, London, was opened for the second International Congress for Sex Research during the week of August 3 to 9 and provided admirable facilities for the meeting. The general reception for delegates preceded the official opening of the congress and provided opportunity for meeting delegates from the various countries.

Arrangements for the congress were ably handled by a British committee of some thirty-five members

with Professor F. A. E. Crew as president, Dr. B. P. Wiesner, general secretary, and Dr. A. W. Greenwood, publication secretary.

Thirty countries were represented with a total registration of approximately three hundred arranged according to numbers—Great Britain, Germany, United States (approximately 35), France, Italy, etc. Almost one hundred papers, presented both in general and in sectional meetings, brought up for discussion a wide range of interests bearing upon sex problems. Predominant, perhaps, were the biological and chemical aspects of the gonad hormones which included discussions regarding hormone production, detection methods, preparation, properties, function and interactions; both the purely biological and clinical aspects were emphasized. Perhaps next in emphasis was the influence of other endocrine glands upon sex, in particular the pituitary gland. Other interests involved dietary influences affecting sex, sex control, modifications of secondary sex characters, as well as gonads themselves, contraceptive methods, the sociological and psychological aspects as well as psychoanalysis. An afternoon of demonstrations in the Cambridge laboratories arranged by Professor F. H. A. Marshall, Drs. Hammond, Walton and many others was a pleasant and profitable feature.

Under the direction of the British committee the congress was held to a commendable scientific level and was a decided success. It has been proposed to hold the third congress in Paris in 1933.

CARL R. MOORE

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE ON THE PACIFIC COAST

SUMMER MEETING OF 1931

THE first of the new series of summer meetings of the American Association for the Advancement of Science will be held at Pasadena, California, from Tuesday, June 16, to Saturday, June 20, 1931. The California Institute of Technology, the Huntington Library and Art Gallery, and the Mount Wilson Observatory will serve as hosts. Detailed preparations for the meeting are in charge of the local committee (Paul W. Merrill, *chairman;* H. D. Babcock, *secretary*), with the cooperation of the executive committee of the Pacific Division (E. G. Martin, *chairman;* J. Murray Luck, *secretary*). The section organizations are not required to take part in this meeting, but sections and associated societies (or their western branches) will be welcome. Communications concerning organizations that plan to take part should be sent to Dr. J. Murray Luck, Stanford University, as soon as possible and carbon copies should be sent to the Washington office of the association.

THE FIRST WINTER MEETING OF THE PACIFIC DIVISION

The first winter meeting of the Pacific Division, A. A. A. S., will be held at Stanford University, California, on December 22 and 23. The Society for Experimental Biology and Medicine, Pacific Coast Branch, and the Western Society of Naturalists will meet on the afternoon of December 23 for the presentation of papers. A program of papers contributed by invitation is being organized by the latter for the afternoon of December 22.

A committee of Pacific Coast geologists is arranging a symposium on the tertiary history of California for the morning of December 23. The following subjects will be considered:

1. The tertiary orogeny of California.
2. The bearing of fossil plants on the tertiary orogeny of the state.
3. The bearing of molluscan faunas on the tertiary orogeny of the state.
4. The bearing of vertebrate faunas on the tertiary orogeny of the state.
5. Tertiary igneous activity in California.

The program, as tentatively arranged, is as follows:

Monday, December 22:

10:00—Registration, Stanford Union.
11:00—Scientific film of general interest.
12:15—Luncheon, Stanford Union.
1:30—Western Society of Naturalists. Session of papers contributed by invitation.
6:00—Dinner, Stanford Union.
An after-dinner program is under arrangement. A reception, tendered by the university, will follow.

Tuesday, December 23:

9:00—Symposium, "The Tertiary History of California."
12:15—Luncheon.
1:30—Sessions of participating societies.
6:00—Dinner.

Copies of the program will be available for distribution at the registration headquarters. Titles of papers for presentation in the Tuesday afternoon sessions will not be printed in the association program and need not be submitted in advance of the meeting.

J. MURRAY LUCK, *Secretary,*
Pacific Division, American Association for the Advancement of Science

SCIENTIFIC NOTES AND NEWS

ACCORDING to an Associated Press dispatch from Stockholm, the Nobel prize in physics has been awarded to Sir Chandrasekhar Venkataram Raman, F.R.S., professor of physics in the University of Calcutta, known for his work on the diffusion of light and the "Raman effect." The prize in chemistry has been awarded to Dr. Hans Fischer, professor of organic chemistry at the Technical Institute, Munich, known for his work on blood, especially the synthesis of hemoglobin. As has been already announced, the prize in medicine has been awarded to Dr. Karl Landsteiner, of the Rockefeller Institute for Medical Research.

A "JORDAN Anniversary Number" of *Copeia*, the journal of the American Society of Ichthyologists and Herpetologists, will be issued at the end of the year, as a tribute to David Starr Jordan, dean of American ichthyologists, who will be eighty years of age on January 19. Any one desirous of helping to make this project a success, is requested to communicate with Dr. Carl L. Hubbs, secretary of the society, at the Museum of Zoology, University of Michigan, Ann Arbor.

PROFESSOR ALBERT EINSTEIN has accepted an invitation to undertake special research work at the California Institute of Technology and Mount Wilson Observatory. He will be accompanied by Dr. Walter Mayer, of the University of Vienna, as scientific assistant. Professor Einstein expects to sail on November 30 on the *Belgenland*, which goes to California with a stop at New York. He plans to return by way of New York in February, proceeding to Oxford to fill a lecture engagement.

MR. DAVID LUMSDEN, horticulturist of the Plant Quarantine and Control Administration of the U. S. Department of Agriculture, was awarded, on October 18, the silver cup presented each year by the American Orchid Society for outstanding services in promoting orchid cultivation.

A DINNER in honor of Dr. John Oliver La Gorce was given by the trustees of the National Geographic Society in Washington on November 5 in celebration of his twenty-fifth year of association with the society. Dr. La Gorce is vice-president of the society, a life member of its board of trustees, and associate editor of the *National Geographic Magazine*. Dr. Gilbert Grosvenor, president of the society, presided.

THE Board of Scientific Directors of the Rockefeller Institute for Medical Research announces the promotion of Dr. Robert E. Steiger and Dr. Alphonse Walti from the rank of assistant to that of associate on the scientific staff.

MR. LEONARD L. ELDEN, technical adviser to the general superintendent of the Edison Electric Illuminating Company of Boston, has been appointed vice-president and member of the executive council of the United States national committee of the International Electrotechnical Commission.

DR. ELWIN E. HARRIS, for the past seven years professor of organic chemistry in the University of North Dakota, has joined the Derived Products section of the U. S. Forest Products Laboratory at Madison, Wisconsin. Dr. Harris will be engaged in the federal laboratory's investigation of lignin which has been inaugurated on an intensive basis.

KENNETH A. AMSTUTZ, formerly chemist with the Dow Chemical Company, has become assistant professor of chemistry at Miami University, Oxford, Ohio.

ON the recommendation of the scientific advisory committee, the British Empire Cancer Campaign has made a further grant of £150 to Dr. J. C. Mottram, pathologist at the Radium Institute, London; £300 to Mrs. E. K. Dawson, of Edinburgh, for the continuance of investigations into mammary cancer, and £250 to Mr. E. Nevill Willmer, at the physiological laboratory, University of Cambridge.

PROFESSOR W. L. JEPSON has recently returned from England where he spent four months in research upon flora of California problems at the herbarium of the Royal Botanic Gardens, Kew, and at the Natural History Museum, London. He was also a delegate of the University of California to the International Botanical Congress at Cambridge.

PROFESSOR WILLIAM I. MYERS, of the department of agricultural economics, Cornell University, sailed on November 13 for Porto Rico, where he will undertake an investigation of agriculture and cooperative organizations for the Federal Farm Board.

DR. ARTHUR S. EAKLE, professor of mineralogy at the University of California, is conducting a systematic survey of minerals in the Hawaiian Islands, making his headquarters with the geology department of the University of Hawaii.

DR. ROSS A. GORTNER, chief of the division of agricultural biochemistry, of the University of Minnesota, will give a series of lectures at the University of Wisconsin from December 9 to 12, under the auspices of the Wisconsin Alumni Research Foundation. The series will include two general lectures on "The Application of Colloid Chemistry to Biological Problems," and on "Biochemistry and the Problem of Organic Evolution." In addition Dr. Gortner will

lecture before specific groups on his own researches in the field of colloid chemistry and the application of physico-chemical methods to biology and medicine.

DR. OLIVER HAZARD PERRY PEPPER, professor of clinical medicine in the University of Pennsylvania School of Medicine, will give the sixth annual Scripps Metabolic Clinic Lectures at La Jolla early in January, under the auspices of the Scripps Lectureship Endowment, to members of the San Diego County Medical Society. The meeting will be primarily in the form of lecture-clinics.

SIR FRANK DYSON, British Astronomer Royal, delivered a lecture at the Sorbonne, Paris, on November 7, on "The History of Greenwich Observatory." The lecture was arranged by the Association France-Grand Bretagne.

PROFESSOR P. SCHERRER, lecturer in the department of physics of the Technical Institute, Zurich, will during the first ten weeks of the term deliver a set of descriptive, experimental lectures on various phases of modern atomic theory at the Massachusetts Institute of Technology, and Professor J. A. Schouten, of the Technische Hoogeschool, Delft, Holland, visiting professor on the Rockefeller Foundation, will deliver a series of lectures on "The Geometry of Linear Displacements."

FIVE illustrated lectures by staff members of the Carnegie Institution of Washington will be given during November and December at 8:30 P. M. The dates and lectures are as follows: November 18, "Development of the Egg as seen by the Embryologist," Dr. George L. Streeter, director, department of embryology; November 25, "Development of the Egg as seen by the Physiologist," Carl G. Hartman, staff member, department of embryology; December 4, "Development of the Egg as seen by the Geneticist," Charles W. Metz, staff member, department of genetics; December 8, "Ancient Cave Life in Southern Nevada," Chester Stock, research associate in paleontology; December 10, "Exploration of Space," Edwin P. Hubble, astronomer, Mount Wilson Observatory.

THE thirty-second annual meeting (the 168th regular meeting) of the American Physical Society will be held in Cleveland in the Physics Laboratories of Case School of Applied Science and Western Reserve University on December 30 and 31, in affiliation with Section B—Physics—of the American Association for the Advancement of Science. The Josiah Willard Gibbs Lecture will be delivered on Tuesday afternoon at 4:00 o'clock by Professor E. B. Wilson, of Harvard University.

THE sixteenth annual meeting of the American Association of Petroleum Geologists will be held at San Antonio, Texas, on March 19, 20 and 21, 1931. The Gunter Hotel is to be headquarters for the convention. The San Antonio section of the association will be the host for the occasion, with the active cooperation of the San Antonio Chamber of Commerce and the local hotels. Concurrent meetings will be held by the Society of Economic Paleontologists and Mineralogists, a technical division of the American Association of Petroleum Geologists, and by the Society of Petroleum Geophysicists. Special features will be a moving picture lecture by Dr. Laurence Gould, geologist and second in command of the Byrd South Polar Expedition, and a moving-picture presentation of the making of airplane maps for oil companies.

THE third International Congress of Radiology will be held in Paris at the end of July, 1931, the sections being Roentgen-diagnosis, Roentgen- and Curie-therapy, radio-biology, radio-physics, natural and artificial heliotherapy and medical electrology.

WE learn from *Nature* that the fifth congress of Polish Physicists, held at Poznań from September 24 to 27, attracted more than three hundred members. The congress was divided into two sections, nearly equal in numbers—an educational section and a scientific one. The members of the latter section represented all centers of physical research in Poland, many of which were created after the recovery of the political independence of that country. The congress was held under the presidency of Professor M. Wolfke, of the Technical Institute, Warsaw. Seventy-two experimental and nine theoretical papers were presented, showing a considerable increase of scientific activity since the last congress, held at Wilno in 1928. The Physical Institute of the University of Warsaw, the director of which is Professor Pieńkowski, contributed more than twenty papers.

IN regard to the White House Conference on Child Health and Protection which opened in Washington on November 19, President Hoover is reported to have said: "The governors have appointed their delegates and various mayors their delegates as well as delegates from municipalities and associations interested. So far over 2,500 delegates have been appointed. Some 16 months ago I announced the convening of this conference. A number of committees were appointed for research and investigation and now total over 1,200 members covering every field and phase of child problems. The committees will be able to lay before this conference the most complete survey ever placed before this country on all questions relating to children's health and protection covering all problems, including deficient and delinquent children, to enable

the conference to come to conclusions on the material gathered. Those conclusions will have a very important effect in the activities of states and municipalities on these problems. I do not think—I know—that there never has been so exhaustive an investigation and presentation of the subject as will be made at the conference."

MCGREGORY HALL OF CHEMISTRY at Colgate University will be dedicated on December 5 and 6 instead of the dates given in the issue of SCIENCE for October 24. On Friday the fifth, the formal dedicatory exercises will be held in the afternoon, followed by inspection of the laboratory, a dedication banquet at 6:30 P. M., and a popular address at night. On Saturday there will be held a conference on the training in chemistry required for teaching, research, industry and medicine. The names of the speakers will be announced later.

APPLICATIONS must be on file with the U. S. Civil Service Commission at Washington, D. C., not later than November 26, for the position of toxicologist, with a salary of $3,800 to $4,600 a year; for associate pharmacologist, $3,200 to $3,800 a year, and for associate physiologist (apiculture) and associate technologist (honey), $3,200 to $3,800 a year, not later than December 10. These examinations are to fill vacancies in the Bureau of Entomology, Department of Agriculture, for duty in Washington, D. C., or in the field. Competitors for these positions are not required to report for examination.

Industrial Engineering and Chemistry reports that the government of the Union of South Africa invites applications from suitably qualified research chemists for appointment to the post of director of the Fuel Research Institute, Union of South Africa. The salary attached to the post is £1,000 per annum, increasing to £1,200. Applications, giving full information, must reach the chairman, Fuel Research Board, Department of Mines and Industries, Pretoria, South Africa, on or before January 15, 1931.

THE Geneva correspondent of the New York *Times* sends further details regarding the construction of the highest international scientific institute in the world, 11,340 feet up on the Jungfraujoch. It will be started soon, as the voluntary subscriptions received from the different countries are sufficient. America has contributed to the building fund $21,700, England and Germany $20,000 each, France and Austria $10,000 each. The Jungfrau Railway Company has given $40,000 and the Swiss Alpine Club $5,000. The Swiss government has promised $10,000 and an annual subsidy of $2,000 for ten years to cover current expenses. The object of the institute is to permit scientific men from all parts of the world to make researches, at high altitude, concerning meteorology, astronomy, electricity, physiology and other sciences. During the period of building the engineers and workmen will be lodged in a modern underground hotel which will be built inside the face of the rocks so as to protect them from avalanches and heavy snowfalls which are frequent on the Jungfrau during the winter months.

THE *Journal* of the American Medical Association says that the government of India has accepted the offer of the Rockefeller Foundation to build and equip an All-India Institute of Hygiene in Calcutta. Lieutenant Colonel A. D. Stewart has been appointed director-designate, a site is being acquired and all provisional plans have been made. The institute will afford opportunity for research and teaching in problems of public health with special reference to Indian conditions and will cooperate with the present Calcutta School of Tropical Medicine and the affiliated Pasteur Institute, the Carmichael Hospital for Tropical Diseases and the Leonard Rogers Laboratories. The latter has a special staff working on leprosy, kala-azar, hookworm, intestinal diseases and filariasis. The Calcutta school published more than eighty technical papers on tropical problems last year.

PLANS for the establishment of a research institute to be connected with the Chiaotung University of Shanghai have been completed by the Ministry of Railways of China. College graduates will receive there the opportunity to study industrial and economic problems. The China Foundation for the Promotion of Education and Culture has given $50,000 to the funds of the new institute. A College of Natural Science containing departments of higher mathematics, physics and chemistry will also be added to Chiaotung University.

A COLLECTION of Diptera, with approximately 12,000 specimens, has been presented to Purdue University by Dr. C. F. Adams, director of the bacteriological laboratory of the Indiana State Board of Health, formerly dean and entomologist of the College of Agriculture of the University of Arkansas. Dr. Adams has retained the Mycetophilidae and a named set of the Culicidae, in which groups he will continue his studies.

IT is stated in *Nature* that the Mond Nickel Company, London, has arranged three exhibits showing aspects of the nickel industry, which are available, free of charge, to colleges, technical institutions, schools, etc., in connection with conversaziones or to illustrate class or open lectures. Exhibit No. 1, illustrating "The Versatility of Nickel," was available last

year. Exhibit No. 2 illustrates "The Extraction of Nickel by the Mond Process," and consists of flow sheet, photographs, samples of intermediate and fine products, letterpress and booklets. Exhibit No. 3 illustrates "The Properties and Applications of Nickel and its Alloys," and consists of samples of products made in many different alloys, photographs, letterpress and booklets. Lectures illustrated by traveling exhibits or lantern slides are also given by members of the firm's staff.

DISCUSSION

PHYSIOLOGICALLY ACTIVE COMPOUNDS

IT has perhaps become customary to associate very intense biological activity chiefly with "toxines," "enzymes" and other bodies which are the despair of the organic chemist.

This attitude may have resulted partly from the fact that pharmacologists have seldom expressed the results of their experiments in striking terms. Professor A. J. Clark[1] has recently recalculated some pharmacological data in the literature and expressed the results in what may be termed an almost sensational manner. Thus he finds that doses of acetyl-choline which I had found sufficient to cause a distinct fall of blood-pressure in a cat could only produce a concentration equivalent to 1 mg in 500,000 gallons of blood. Clark has found that even smaller concentrations may affect the frog heart and shows that the volume of the cell of the frog heart is about 3.4×10^{11} times greater than that of the molecule of acetyl-choline. "This relation in size is similar to that between a large whale (100 tons) and a midge (1/3 mg). The remarkable fact is that a few thousand of these molecules when attached to the cell are sufficient to depress its activity."

My data could have been expressed in a different way: 1 grain (originally defined as the weight of a grain of wheat) would suffice to lower the blood-pressure of more than a thousand million cats; yet this dose might not kill a single cat. Clark also calls attention to the work of Loewi which indicates that stimulation of the vagus liberates acetyl-choline around the heart cells and in this way slows or weakens the heart. I had found indications of the presence in the adrenal glands of compounds which were far more active than choline and which seemed to yield choline on chemical treatment; this observation led me to prepare acetyl-choline and so to the discovery of the remarkable physiological activity of this compound. Recently Dale and Dudley have succeeded in isolating acetyl-choline from the spleen, and Kapfhammer and Bischoff believe that they have found it in ox blood.

Dale and Richards found that histamine, a compound widely distributed in animals, is active in even smaller doses than is acetyl-choline.

Clark also calls attention to a number of other very active "drugs" (thyroxin, epinephrine and secretin) which are formed in the body and concludes, "Modern investigations show, therefore, that there is a complex system of control of the body by means of the release of drugs."

The possibilities of finding drugs useful in the treatment of diseases by the pursuit of such studies are obviously very great, but at present very little scientific work is being done along these lines. Ehrlich more than thirty years ago reproached the medical profession and those responsible for the direction of medical research for abandoning to chemists and commercial interests research in this field which he termed the "ureigenstes Gebiet" of the medical profession.

REID HUNT

HARVARD MEDICAL SCHOOL

SALINITY AND SIZE

IN the *American Naturalist* for March–April, 1930, Federighi[1] notes the smaller size of *Urosalpinx cinerea* from the saline waters at Beaufort, North Carolina, as compared with snails of this species from the less saline waters at Norfolk, Virginia, and he refers to observations by Vernon,[2] Flattely and Walton[3] and Hubbs upon the effects of salinity upon size. Hubbs noted that "within certain limits, size is directly proportional to the salinity," while Vernon and Flattely and Walton "maintain that the more saline waters tend to restrict the size attained."

It may be of interest to note that in a little paper[4] I published in 1904 I described dwarf specimens of *Neritina virginea* in the very salt shore ponds near Port Henderson, Jamaica, West Indies, and similar dwarfs from the almost fresh water in the mouths of two rivers on the northern side of the same island.

[1] *Jl. Soc. Chem. Ind.*, June 27, 1930.

[1] Federighi, "Salinity and the Size of *Urosalpinx cinerea* Say," *American Naturalist*, March–April, 1930.

[2] Vernon, "Variation in Animals and Plants," Henry Holt, 1903.

[3] Flattely and Walton, "The Biology of the Sea Shore," Macmillan, 1923.

[4] Metcalf, "*Neritina virginea* variety *minor*," *American Naturalist*, 38, 1904.

The dwarf forms from either region have less than half the length or breadth of the forms on the ocean shore.

Interesting experiments might be made upon this widely distributed *Neritina* to see if it is so adapted to waters of an optimum salinity that rearing it in either more or less saline water causes it to be of smaller size.

MAYNARD M. METCALF

THE JOHNS HOPKINS UNIVERSITY

MOLLUSCAN HOSTS IN NORTH AMERICA FOR HUMAN FLUKES

PERHAPS the most impressive thing to the student of trematodes is the relatively great number of digenic worm parasites affecting man that are indigenous to the Orient, Africa, India and Europe. Equally striking is the lack of fluke parasites which affect man in North America. These significant facts may be explained in terms of man's distribution during geologic time. Such facts should encourage research on our own molluscan fauna taxonomically and experimentally to determine the probability and possibility of the dangerous exotic flukes becoming established on this continent.

Has any one yet tried to infect the North American relatives of *Melania, Katayama, Oncomelania, Bulinus, Bithynia, Planorbis coenosus* or *Segmentina* with the miracidiae of man's most dangerous flukes? These genera harbor such flukes in the Old World. Does any one know whether the Japanese snail, *Viviparus malleatus,* will not carry any of these dangerous flukes? This snail is already well established in the Kern River and the irrigation ditches about the city of Bakersfield, California. There are many orientals working in close contact with these snails in California. Is any one sure that these gardeners can not infect these snails with any one of the many flukes of the Orient? Likewise *Bithynia* has been introduced from Europe and *Viviparus* and *Segmentina* also have species native to North America.

Diseases such as yellow fever, malaria, sleeping sickness and filaria are carried by two or more species of the same genus of insect and, in the case of filaria, by two different genera. The distribution of these diseases now depends on the distribution of the species of animals that can carry them. Man is no doubt still giving his diseases to mosquitoes and snails that are capable of being infected because of their relationships to the original hosts.

Many of the animal parasites of man in North America are exotic forms. The hookworm of the South is supposed to have come from Africa with the slaves. Many other worms have had a similar history. In North America, rich in trematodes in other orders of vertebrates, we find few important flukes, except those brought in by foreigners, which affect man. It may not be impossible, however, for them to become established if the proper snail host should be introduced, or if the immature stages could live in a closely related snail. Such may be a possible explanation of the human fluke, *Paragonomus westermani,* in the New World.

LLOYD G. INGLES

BAKERSFIELD JUNIOR COLLEGE

A BITUMINOUS FOSSIL PLANT FROM THE TRIASSIC OF NORTH CAROLINA

A SPECIMEN of solid hydrocarbon (bitumen), in the shape and with the external markings of a flattened tree root, was recently taken from the roof of the Cumnock Coal Mine of the Deep River Triassic Coal Field of North Carolina. This peculiar specimen is black in color, brittle and has many pores, marking the presence of former gas bubbles. The specimen was about 30 feet from a large, basic, igneous dike which cuts through the Cumnock coal seam. This igneous dike has altered the bituminous coal to natural coke (carbonite) for a number of feet on either side of the dike.

It is apparent that this bituminous fossil plant root was formed by the filling of a root cavity by the bitumen distilled from the coal in the formation of the natural coke.

Local deposits of solid hydrocarbons in the Triassic sediments or Mesozoic basalts have been mentioned by a number of scientists, as J. G. Percival, T. S. Hunt, E. S. Dana and I. C. Russell. These deposits have been cited from Gaspé, New Jersey and Connecticut. The occurrence in these localities is in amygdaloidal cavities in the cellular basalt or along joint planes in the Triassic rocks.

The source of the bitumen in the deposits in Gaspé and New England is doubtless from the igneous dikes which have picked up the hydrocarbons in their course through carbonaceous rocks. The hydrocarbons thus gained were deposited in the most accessible rock openings, the joint planes and amygdaloidal cavities. This latter type of opening does not occur in the basic rock deposits in North Carolina, since in this section of the country the Mesozoic basic rocks are entirely intrusive in character and non-cellular, but the solid hydrocarbons do locally occur along the joint planes.

There are probably many fossil bituminous plant stems in the Triassic coal field areas of North Carolina and Virginia, but as far as I know there has been up to the present no record of such discovery.

WM. F. PROUTY

UNIVERSITY OF NORTH CAROLINA

THE MEANING OF NATURAL SELECTION

IN the issue of SCIENCE for October 24 is an article on "The Organic World and the Causal Principle" in which the question of natural selection as a cause is discussed, and the fact is entirely overlooked that natural selection in the minds of most men has come to mean something different from what it did to Darwin.

The authors of the article appreciate that to Darwin it meant a rule or method according to which true causes acted, but like so many other terms, this one, according to the genius of our language, has unfortunately acquired a derivative meaning, and most people now mean by it those true causes which act according to this rule or method. It was Hobbes, I think, who stated that most discussions end where they should have begun, namely, in defining the meanings of the words used.

FRANCIS RALSTON WELSH

A CORRECTION

DR. CALMAN has called my attention to the identity of *Cancer luederwaldti*,[1] recently described from the coast of Brazil, with *C. pagurus*, the European edible crab. Its occurrence in Brazil needs confirmation. The error but emphasizes the desirability of world monographs rather than local faunas, a subject referred to by Dr. Calman in his recent address on the taxonomic outlook in zoology.[2]

MARY J. RATHBUN.

U. S. NATIONAL MUSEUM

SPECIAL CORRESPONDENCE

PROGRESS OF THE GEOLOGICAL SURVEY OF CALIFORNIA

A YEAR ago last July a geologic branch was established[1] as part of the California State Division of Mines, and $20,000 for the biennium was set aside for its work. With the many facilities of the division at hand and with the cordial support of various institutions in the state it has been possible to make a broad step in advance towards fulfilling the future plan of the work.

A ten-year program has been favored by the State Mining Board and arranged for by the state mineralogist, Walter W. Bradley, during which time it is planned that the general state geologic map, now in preparation, should be finished. The base of this map has already been issued by the U. S. Geological Survey, and the compilation of geologic data is well under way, both federal and state officials cooperating in the task.

The state geologic map will serve as a general clearing place for as many data as can be secured. It has been found that about 26 per cent. of the state is covered by published detailed and semi-detailed geologic maps, 32 per cent. by unpublished material, while 42 per cent. remains practically blank, and a large portion of the blank area has no satisfactory base maps for the field geologist to use.

Most of the area covered by unpublished data has much material sufficient for a map of this scale (eight miles to the inch) but not complete enough for publication as detailed sheets. Many areas have been worked over, and the manuscripts laid aside, never to be completed by the original authors. A large part of California has been geologically mapped through the work of the geological department of the Southern Pacific Company. Large tracts of country covered especially by Tertiary sediments have been worked intensively by various oil companies, and though the details of their findings may not be at present available for publication the general areal geology suitable for the state map will be in most cases readily available as soon as the compilation of other data has been completed.

The state geologic map is to be issued in three separate sheets, covering southern, central and northern California, respectively, each published as it is completed. The two dividing lines will probably be through the thirty-sixth and thirty-ninth parallels. It is thought that the southern sheet will probably be first to get into publication, owing to the greater percentage of work covering it, and for the reason that the mapping of blank areas in the south can be completed more rapidly than in the more mountainous and wooded northern country.

Though the preparation of the state geologic map is an important item in the work of the state survey, it is by no means to be the extent of its endeavor. Its function includes the study of the problems of oregenesis, underground water, non-metallics, geology related to engineering problems, geology of the oil fields, stratigraphy and many other phases of this great applied science. At a recent meeting of the State Mining Board the name Geological and Economic Mineral Survey was adopted as the most suitable name for this new geologic branch of the Division of Mines.

[1] SCIENCE, 70: 554, December 6, 1929.

[1] *Bull.* U. S. Nat. Mus. 152: 200, pls. 86–89, 1930.
[2] SCIENCE, 72: 279, September 19, 1930.

Thus far the work undertaken by this new survey has been cooperative, especially with geologists associated with universities. The first work to be published will be a very comprehensive bibliography of the geology of California, prepared by Dr. Solon Shedd, of Stanford University. This is now in the hands of the state printer.

By giving some financial assistance to certain worthy research workers, the geological survey of the Division of Mines has been able to foster a number of extensive field investigations this summer. The Weaverville quadrangle in northern California is being completed by Dr. N. E. A. Hinds, while in southern California Dr. C. D. Hulin has been mapping the Searles Lake quadrangle, a work which supplements his bulletin on the geology and ore-deposits of the Randsburg quadrangle. The results of the work of these geologists (both members of the faculty of the University of California) will be issued as separate bulletins covering in detail the problems of their respective areas.

The Division of Mines is making it financially possible for eight graduate students to carry on the necessary field work for their advanced degrees, with the result that several important areas in the state are being mapped. These are as follows: Elizabeth Lake quadrangle, by Edward C. Simpson; Sebastopol and Duncans Mills quadrangles, by F. S. Johnson; two areas in San Bernardino County, one by John C. Hazzard and the other by Dion Gardner, and a portion of northeastern Madera County by Homer D. Erwin, all of the University of California. The geology of the southern and western part of Mono County is being mapped by Evans B. Mayo, formerly of Stanford, but now of Cornell. A large part of the San Jacinto quadrangle has just been finished by Donald Fraser, of Columbia University. Underground mining geology in Grass Valley is being carried on by Robert L. Loofbourow, of Stanford University, working under the direction of the U. S. Geological Survey in cooperation with the Division of Mines. Mr. George Green, of Stanford University, is just beginning a study of the underground geology of the coast tunnels of the Hetch Hetchy aqueduct. In addition to these special studies, Mr. Charles V. Averill, district mining engineer of the Division of Mines in northern California, is making a study of the geology of the mines of the Shasta quadrangle, correlating his work with that secured from the Southern Pacific Company. Besides these projects there are many other new plans under consideration, such as cooperation with the U. S. Geological Survey in the publication of many data already in manuscript form.

The work of the new survey is, therefore, well under way. Cataloguing of data is well in hand, the bibliography is completed and the state map is in preparation. Altogether twelve field men, together with several assistants, are contributing new data to the geology of California.

Enthusiasm for the undertaking has been met on all sides, and cooperation of all sorts has been more than cordial. We now hope that the State of California will favor the continuance of the geological study and will encourage the building up of a strong geological survey by granting in the future liberal appropriations for the work.

OLAF P. JENKINS
CALIFORNIA STATE DIVISION OF MINES

SCIENTIFIC BOOKS

A History of Experimental Psychology. By EDWIN G. BORING. New York; The Century Company, 1929, pp. xvi, 699.

IT is extraordinary that there should have appeared within a single year two such important histories of psychology as Gardner Murphy's "Historical Introduction to Modern Psychology" and the present work.

In contrast with most earlier treatments of this subject, both these books are the productions of men who are intimately in touch with the enterprises of present-day psychology. As a consequence, they supply a background which the active investigator can hardly afford to neglect. And the expert in another science who would cultivate a serious acquaintance with psychology could adopt no more profitable means than that of reading either or both of these historical works.

Although the present review is of Professor Boring's book, it is not entirely outside that purpose to make a distinction between it and the Murphy history. If one is interested in obtaining information in regard to the development of some special topic of modern psychology, Dr. Murphy's book will probably offer prompter service. If, on the other hand, one is interested in the present science of psychology as the outcome of a large and intricate adventure of the human mind, then one would better turn to Boring.

Histories of psychology have been in the habit of starting out with a discussion of ancient conceptions of soul or mind. When treated in detail this is an elaborate subject and one which, unfortunately, bears no obvious relation to modern psychological research. Histories which begin with such minor issues have seldom given understanding treatment to the impor-

tant sources of present psychology. They have thus tended to make the past seem meaningless and the present trivial. Professor Boring has adopted a more fruitful procedure. Since he is interested in the history of a *science* of psychology rather than in all attempts to deal with the mind, he finds his significant starting point in the emergence of scientific modes of thought and in the development of controlled observation as a basis for such thought. Although he is clearly conscious of a continuously important relationship between philosophy and science, he believes that the essential qualities of science depend upon a clearly defined distinction between the two.

> It seems probable . . . that the cleft between philosophy and science is caused by a more fundamental human individual difference than are any of the clefts between the different sciences, and that science split off from philosophy, in this personal way, largely because of the rise of the experimental method. In the first chapter of this book we have said little of the great Aristotle and more of the lesser Aristarchus, who measured the distances to the sun and the moon, and of the lesser Eratosthenes, who measured the size of the earth. These two men were experimentalists, and the contrast of the experimental with the rationalistic method shows clearly in the simple beginnings of the former. Both philosopher and scientist require imagination, but the imagination of the scientist is limited by the scope of the experiment. . . .

Perhaps nothing illustrates better the general outlook and emphasis of Professor Boring's book than the composition of his first chapter. "The Beginnings of the Scientific Attitude," "Greek Philosophy and Greek Science," "The Emergence of Observation as a Method in Science," "Early Physics and Biology," "The Rise of Modern Science," "The Development of Biological Science": these are the real sources of the present science of psychology, and it is with them that this history begins. As a result one feels from the first why and how psychology, as we now know it, came to be. In the case of most of the earlier histories of psychology nothing of the kind was true. Their authors, weighted down by antiquarian interests, have plodded a laborious, chronological trail from the forerunners of Aristotle to some convenient modern stopping point.

Scientific psychology, though not without relationship to speculation about the mind, is nevertheless the child of experimental physiology, which was in turn the child of experimental physics. As Boring says, there may be some question as to whether biological and then psychological inquiry ought to have followed the pattern laid down by physics. But he recognizes that he is writing history, and he wisely turns aside from such issues of *ought*.

> The actual fact is that science was what physics and astronomy were. Scientific physiology developed because physics had provided a method for it, and physiology was scientific because it held to this method. Later we shall see that physiology gave birth to experimental psychology, at first called "physiological psychology," in much the same way that physical science gave birth to physiology.

Working in this frame of mind, Boring devotes the first long section of his history to those developments within the physiology of the first half of the nineteenth century which proved especially influential upon experimental psychology. This period is taken to be peculiarly important because it is just prior to the emergence of the independent science of experimental psychology and also because many of the accomplishments of the physiology of those years were as much psychological as physiological. Throughout the volume Boring is always striving to bring out the larger movements and more significant ideas. In his treatment of this physiological psychology of the early nineteenth century he begins with the Bell-Magendie law and then turns to the velocity of the nervous impulse. Regarding the first, he tells us that:

> There is little danger of overestimating the importance of these discoveries for the physiology of the nervous system. Up to this time, the nerves had been supposed to transmit promiscuously "the powers of motion and sensation." Bell's work established the fundamental dichotomy of function which has remained the implicit assumption of almost all research upon the nervous system for a century.

Similarly, Boring notes how revolutionary was the discovery that the nervous impulse is not instantaneous. The slowness of this transmission constituted an invitation for the mechanical analysis of behavior. Like Bell's discovery, it suggested that study of human action is possible in a way that it could not be if action were the instantaneous outcome of an indivisible neural flash.

Included in the discussion of early physiological psychology are chapters on the personal equation and on hypnotism. Although the first of those topics had its origin in astronomy rather than in physiology, it had a great deal to do with the rise of the classic reaction time experiments, which soon became closely related to the problem of the speed of neural processes. Hypnotism did not come into importance in the physiological laboratory, nor has it ever received much attention from orthodox scientific investigators. Most of what we now know of the subject was, however, determined by medical men and it is presumably for this reason that the topic is treated at this

point. It is interesting to note that hypnotism is one of the foundation stones of present-day psychology which has hardly any structure erected upon it. Boring is certainly justified in describing hypnotism as an important scientific chapter of the early nineteenth century, but its importance as a forerunner of experimental psychology is a matter yet to be determined.

Although it is Boring's strong contention that the facts and problems of psychology grew up within science—especially within physiology—he clearly recognizes that experimental psychology was not split off as an independent subject until what was psychological in science at large came into contact with a philosophical psychology which since antiquity had existed as a field of speculative activity. The second section of the present history is devoted, therefore, to "The Preparation for Experimental Psychology within Philosophical Psychology." In content this topic is more like what has conventionally gone under the name of history of psychology. But from the viewpoint of a present-day psychologist, Boring handles philosophy with a peculiarly happy capacity for selection. After a brief treatment of Aristotle, he goes at once to Descartes. Then follow in turn: Leibnitz, Locke, Berkeley, Hume, Hartley, the Mills, Bain, Spencer, Herbart and Lotze. The important contributions of these men are set forth with remarkable clarity and quite fully enough for the purpose of the present book. The treatment of the development of association theory in England is much the best brief account that has come to the reviewer's notice.

There are some 670 pages of text in Boring's history and Fechner makes his major entrance on page 265. This gives an idea of the relative space given to the history of psychology after it became experimental. The story of the founding of experimental psychology is told as follows: after a chapter on Fechner there is one on Helmholtz which emphasizes his theories of perception as well as his contributions to the more restricted aspects of vision and audition; then Wundt with the Leipzig Laboratory, followed by a chapter on those three non-Wundtians Brentano, Stumpf and G. E. Müller; the period immediately subsequent to "the founding" is represented by the work of a German group made up of Ebbinghaus, Külpe and Titchener (even though the last lived his professional life in America) and a number of others such as Mach, Avenarius, Lipps, Ziehen, Münsterberg, Kraeplin and Meumann, each of whom for one reason or another lay outside of the main experimental current; a chapter on the act psychology establishes the historical origin and importance of the distinction between content and act and also prepares the way for the understanding of the functional movement later to arise in America and of the *Gestalt* psychology which is still causing excitement in both Germany and America; British psychology is regarded as important for the systematic writings of Ward, Stout and McDougall, for the contributions of Darwin, Romanes and Lloyd Morgan to animal psychology, and for the fundamental operations of Galton in the field of individual differences; and finally there is a chapter on the American pioneers, James, Hall, Ladd, Scripture, Baldwin and Cattell. All this is a long and difficult piece of writing which it is hard to characterize except in general terms. Perhaps the task could have been better done, but it is the reviewer's belief that no living man could have done it so clearly and almost simply and yet so expertly. Professor Titchener had the knowledge required for this task, but even had he undertaken it, he probably would not have done as well, because, while he was capable of superb exposition at the elementary level, he was hideously difficult when he aimed to be scholarly. But Boring has exemplified a scholarship that is definitely of Titchenerian order coupled with a directness that his master was able to employ only when he could be dogmatic.

There is much talk of personalities in this account of the early days of experimental psychology, but, as Boring points out, those days were made by personalities. The objective study of reaction times would never have been undertaken simply because some one in Wundt's laboratory thought it was a good idea. It should be of the first importance for psychologists to realize that this idea happened in the head of an American youth whose dynamic character is reflected in the fact that he was Wundt's self-nominated assistant. The introspective method would never have gathered around itself a school in America if Titchener had sought to be a congenial colleague of his American contemporaries.

When a historian comes into current events, he is peculiarly exposed to challenge, and it is Boring's treatment of the movements of American psychology which is most likely to arouse arguments. Functional psychology, experimental animal psychology and mental tests are subjects that all of us have known and fought over since the infancies of our professional lives. But before any questions of personal bias are raised, it should certainly be said that Boring has attacked these difficult contemporary and local questions with every effort to be fair. He has read Dewey and Angell on the general standpoint of functionalism and he has read them sympathetically. It is doubtful whether any careful student will be disposed to disagree with his statement of the aims and claims of these men. Nor is he wrong in pointing out that Angell's students more or less naturally drifted into

applied psychology and animal psychology. As compared with his treatment of the factual discoveries of such a group as Külpe's, his treatment of the achievements of those American experimentalists who have been motivated by a dynamic view-point is, however, very incomplete. The reviewer has the feeling that the pioneer studies of Bryan and Harter and of Book on the acquisition of skill were of substantial importance even for the development of a generalized human mind. Stratton's classic experiment on inverted vision reflected very definitely the theoretic framework of American thought. Thorndike's studies of transfer and fatigue were other influential products of the experimental operation of that larger dynamic view-point which has pervaded America and determined the nature of a large part of the investigation done here. The reviewer has similar feelings in regard to Boring's treatment of animal psychology and the mental test movement. There is an attempt to characterize these subjects, but they are, after all, treated rather as offshoots from experimental psychology than as vital ingredients. Boring recognizes in a word that animal psychology has developed into a more general approach to mind than that afforded by the study of the human subject alone, but he has not paid tribute to the large part that investigations of animal behavior have had in shaping current notions of behavior. He recognizes that mental tests are an important offshoot from experimental psychology, but he gives little stress to the really epoch-making discoveries brought about by this device. The reviewer would hazard the prediction that the discovery of the almost invariably positive correlation of intellectual capacities will sooner or later be regarded as more important even for experimental science than the number of layers which somebody can discern in consciousness. It is not to be concluded from Boring's failure to treat in any detail the development of our knowledge of skill, intelligence and work that he regards these topics as trivial. The explanation seems to lie rather in the fact that he has purposely restricted the meaning of "experimental psychology" to what Wundt meant by that expression—"that is to say, the psychology of the generalized, human, normal, adult mind as revealed in the psychological laboratory." Like Titchener before him, Boring seems to feel that experimental psychology of this type must be kept clear of issues that arise out of application or out of investigations of animal behavior which the original Wundtian theory has always found it so difficult to place. But why should one want to confine oneself to the history of what is left of the Wundtian theory? That is a difficult question. It is especially difficult when one considers that the majority of the present work is an adequate history of "scientific psychology" in a much broader sense. It is only in his treatment of American psychology of the fairly recent past that Boring's interest shows its restriction.

Perhaps the reviewer attaches altogether too much importance to the fundamental, scientific contributions made by those who, in this country, have been dominated by a dynamic and functional point of view. It was not his wish, however, as he laid down this history that Boring had said a word less about occurrences within and close to the Wundtian tradition of experimental psychology. He only wished that the author had gone under the *schools* of functionalism and behaviorism and under the more superficial characters of the movements of application and animal study in order to bring out, as he surely would have brought out, discoveries of fact and the development of theory which have already shown their importance for psychology in its largest and most general sense.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A MODIFICATION IN LANTERN SLIDE PROJECTION TECHNIQUE

IN the teaching of the usual courses in physiology, difficulty is experienced in the presentation of visual material. The usual method, and perhaps the simplest, is to draw the diagrams upon the blackboard during the lecture. This takes too much of the time from a short and busy lecture hour, time better occupied otherwise. Large charts mounted on cardboard are useful but have the disadvantage of being expensive, hard to keep clean, difficult to make and bulky for storage. It is often difficult to make them large enough to be easily seen by a large class.

Moving picture films are becoming cheaper and more accessible but are still expensive, and the exact diagrams and drawings of the individual lecturer are rather difficult to prepare in this way, taking a good deal of time and labor. Alterations are not easy, and still projection is hard on film.

Lantern slides still seem to be the best medium for charts and diagrams. However, the ordinary slide prepared by photography does not pass as much light as is often required when daylight illumination of the room is desired. Darkening a room for lantern slide projection is usually a strong hint to the class to take a nap. The process of preparing

lantern slides by photography is tedious and rather difficult.

A modification of this technique has been in use in our department for some time, and the method has been very convenient for some phases of visual presentation. The materials required are a number of glass plates the size and shape of the ordinary lantern slide, drawing inks of the waterproof type and drawing instruments. The plates may be prepared by cutting up thin window glass or boiling emulsion off of old photographic plates and cutting them up. Very fine pen points and camel's-hair brushes are necessary.

After thorough cleansing of the glass surface, the desired diagram is drawn directly in ink on the glass with fine point pens and brushes, using colored inks as desired. The material to be copied may be first drawn on paper and then the slide placed over it for the ink transference to glass. Details, such as fine shading, are rather difficult to reproduce and may often be better left out. But ordinary line drawings are very easily and quickly reproduced on the slide. Any color combinations may be used and, with care, color washes are often of value.

If the slide is to stand a good deal of wear it may be made fairly permanent by dipping the slide, after the ink has dried thoroughly, in a thin clear solution of rosin in xylol. The edges of the slide may be conveniently bound in black, gummed linen tape. The rosin-xylol coating is not necessary for ordinary use, the slide resisting all but direct heavy rubbing and scratching. Slides may be rapidly and easily altered at will. Fifteen or twenty minutes should be sufficient time to prepare a slide for lecture use.

The lines of even the finest pen are much heavier than the fine shading in photographic slides and therefore stand out heavily on the screen. Full daylight may be allowed to fall on the screen without marked diminution in visibility. The lines of the drawing being the only obstruction to the passage of light rays from the machine to the projection surface, very little light is cut off and a great deal of it is concentrated on the screen. Due to this fact and to the heaviness of the lines, a blackboard may be used as a screen in a daylight-illuminated room. Even the lines in black ink stand out clearly by reason of the intense illumination about them. This makes possible modifications of the usual technique of lantern slide projection.

Manifestly, if the lecturer is sufficiently facile with chalk drawing, the method of building up diagrams as the lecture goes on is best of all. The student sees the picture grow under his eyes at the same time that word pictures are built up by the speaker. However, this takes a good deal of time. Few lecturers are possessed of the magic touch of being able to draw accurately and artistically in a short period of time while simultaneously delivering a lecture. To make this easier, the basic fundamental outlines required may be prepared upon slides and projected upon the board. Then while lecturing the speaker may quickly and easily put in the necessary additions or alterations in chalk. By virtue of their lack of reflecting power, the chalk lines are distinct from the original outlines. Altering or adding is much easier and more rapid than the building up of the entire diagram. An eraser may be run over the board and the original lines left for reference and equilibration.

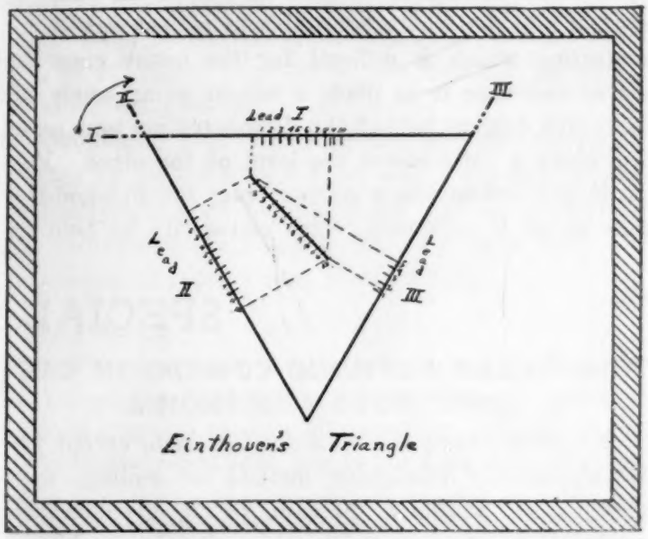

FIG. 1. Einthoven's electrocardiographic triangle. Slide may be projected on board, and after explanations, direction of heart axis may be changed by chalk alterations, simultaneously changing length of projected vectors on triangle to show effect of cardiac axis change on electrocardiographic records.

Uses of this method are numerous. Formulae for chemical equations may be thrown on the board with no figures and the necessary quantities may be written in chalk and altered to suit the problems. Outlines of the body or organs may be thrown on the screen and functions added in chalk (Fig. 1).

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HOW TO MAKE HORIZONTAL DEMONSTRATIONS VISIBLE TO AN ENTIRE CLASS

SOME class demonstrations can be seen only from above. This makes it necessary for small groups to observe them at any one time, which process takes up a great deal of the laboratory period and almost makes it impossible to show effectively such demonstrations in a lecture. At the same time those who

are not viewing the demonstration are disturbed by the walking about. A good example of such a demonstration is that illustrating the effect of dilute nitric acid on the surface tension of a drop of mercury in the presence of a crystal of potassium dichromate. Where a reflecting stereopticon is available it could be used to throw the image upon the screen, but this necessitates darkening the room. A much simpler method and one easily adaptable to almost any demonstration which is difficult for the entire class to see at one time is to place a mirror at an angle of forty-five degrees behind the demonstration and raise the whole a little above the level of the class. For small demonstrations a mirror from the five-and-ten cent stores is adequate. This can easily be held in place upon a board in which two finishing nails of the proper length have been driven at an angle of forty-five degrees, and one nail in the center set back behind these to keep the mirror from slipping.

If the demonstration is small so as to be seen with difficulty from the rear seats, a reading glass of a suitable magnification can be placed at the proper distance from the mirror. In this case the entire demonstration should be placed upon a board or platform so that it can be swung into the line of vision of those on the sides. Other modifications and applications will suggest themselves.

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SPECIAL ARTICLES

TRIANGULAR NEPIONIC COILING IN CARBONIFEROUS AMMONOIDS

A FRAGMENTARY cast of a fossil, which, except for its apparently triangular method of coiling, suggested the umbilical portion of a glyphioceran cephalopod, was collected by the writer in the fall of 1923 from the sparingly fossiliferous lower Pennsylvanian Winslow formation near Fayetteville, Arkansas. An extended search failed to yield additional material. About a year later, however, Dr. N. F. Drake, formerly state geologist of Arkansas, kindly placed at the writer's disposal several cephalopods which had been blasted out of the same formation on Mount Nord within the city of Fayetteville. Upon cleaning the material, the umbilical portions of these cephalopods showed that the coiling of their earlier whorls was distinctly triangular, although the individuals again assumed the ordinary circular method of coiling in their later stages of growth.

A canvass of the literature failed to find any reference to this phenomenon, and the questioning of a number of paleontologists over a period of several years led to the conclusion that it had not previously been observed. Because of the scantiness of the material and its rather poor preservation, as well as the unusual nature of the discovery, the writer has hesitated to record the phenomenon. Recently, however, as a result of continued questioning it was discovered that H. D. Miser, of the U. S. Geological Survey, had in 1927 collected from the Atoka formation near Clarita, Oklahoma, a number of unusual cephalopods which were sent to Dr. R. C. Moore, of the University of Kansas, for study. These specimens also exhibit this same peculiar triangular coiling of the earlier whorls. Furthermore, when this feature was called to the attention of F. B. Plummer and Gayle Scott, who are studying the Carboniferous cephalopods of Texas, they found that upon cleaning out the umbilical area of some of their specimens from the Bend group the same nepionic triangular coiling became apparent. In addition, the writer recently received from John McCormack, of the Oklahoma Agricultural and Mechanical College, a number of cephalopods from the Atoka (?) formation taken from a clay pit near Ada, Oklahoma. Among these specimens there are two individuals which illustrate perfectly this triangular method of coiling. Furthermore, although these specimens are not complete, their last preserved whorls fail to assume complete circularity, though they are somewhat more rounded than the earlier ones. Finally, in examining specimens of Bend group cephalopods in the Walker Museum collection it was found that a number of these individuals also show a definite tendency toward angular coiling in the nepionic and neanic stages, though the triangularity is less pronounced than in the other specimens mentioned above.

Additional interest attaches to this phenomenon since it is apparently confined to members of the cephalopod family Glyphioceratidae, and, as far as present information goes, largely to the genus *Paralegoceras*. Furthermore, although it has now been observed in specimens collected from a number of different localities, the extremes of which are nearly 500 miles apart, all the individuals have been found at essentially the same geologic horizon, that is, lowermost Pennsylvanian. The formations yielding the cephalopods are the basal Winslow, just above the Morrow group, at Fayetteville, Arkansas; the basal Atoka, just above the Wapanucka limestone (which carries a Morrow fauna), at Clarita, Oklahoma, and in north-central Texas, the Smithwick formation, which overlies the Marble Falls limestone (also with a Morrow fauna). The specimens from near Ada

are reported to have come from the Atoka formation also, and the general appearance of the associated specimens supports this statement. No Atoka, however, is shown in the vicinity of Ada on the new geologic map of Oklahoma. Therefore, these particular specimens may have come from somewhat younger beds than did the others.

In conclusion, it is interesting to speculate on the significance and origin of this phenomenon of triangular coiling. Aberrances of one sort or another are not uncommon in cephalopods of the phylogerontic type, but the Glyphioceratidae are simple rather than specialized ammonoids. Furthermore, these phylogerontic aberrances in most cases are also phenomena of individual old age, and not of youth, as is the case in the forms described above. In addition, if all cephalopods in their various stages of development recapitulate their ancestry, as certainly most of them do, these peculiar types point to an ancestral stage in which the adults were triangularly coiled. Not only is no such cephalopod known, however, but it is particularly difficult to imagine the existence of such a type prior to Pennsylvanian time. It therefore seems more probable that the cephalopods described in this note are pathological in respect to the manner of coiling of their earlier whorls. If the latter is the case, however, it is not a little remarkable that the same pathological feature should manifest itself in the same general type of cephalopod, at nearly if not quite the same geologic horizon, and in specimens found over a relatively large area, geographically speaking. Supporting the suggestion that the forms described above may be pathologic is the fact that normal nepionic coiling is found in most associated cephalopods. It has not yet been determined satisfactorily, however, whether some individuals of a certain species may be coiled normally and yet others of that species exhibit the triangular nepionic coiling, or whether this type of coiling characterizes all individuals of each species exhibiting this phenomenon.

The writer would appreciate additional records of the occurrence of this type of cephalopod.

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STIMULATORY EFFECTS OF ULTRA-VIOLET RADIATION UPON HIGHER PLANTS

THE apparently contradictory results of recent investigators concerning the possible stimulation of the growth of higher plants by ultra-violet radiation led to the work reported briefly here. Chief among these investigators are Eltinge[1] and Sheard and Higgins,[2] who have demonstrated that ultra-violet wave-lengths above the lower solar limit, 290 μμ, are beneficial to and seem to stimulate plant growth slightly; and Popp and Brown[3] and Newell and Arthur,[4] who failed to find any stimulation whatsoever in the ultra-violet spectrum.

It appears that these varying results are attributable to differences in methods of irradiation and to other parts of the technique employed by these workers, since similar portions of the spectrum were used in the investigations.

The plants used were tomatoes and cucumbers, reported by Newell and Arthur, and Popp and Brown, respectively, to be unaccelerated in their growth by the radiation from a quartz mercury vapor arc. The experimental groups were the following:

A—Controls.

B—Plants rayed with quartz-lite filter (transmitting to 313 μμ) one half minute on the first day, increased by half a minute on each following day.

C—Plants rayed with quartz-lite filter for 9 minutes daily.

D—Plants rayed with vita-glass filter (transmitting to 289 μμ), with periods as in set B.

E—Plants rayed with vita-glass filter with periods as in C.

The plants were rayed at 100 inches from the arc through a period of five weeks, with 100 plants in each group. The populations of 100 plants as shown by statistical analysis eliminated the factor of individual variation, which had been neglected by previous workers.

It will be noted that the periods of radiation were adjusted so that at the end of the experiment the incremental and constant period groups would have received equal amounts of radiant energy; hence differences in the reactions of the plants subjected to the two methods are attributable only to the differences in the arrangement of the irradiation periods, not to differences in amounts of energy received.

In general, the results point to definite stimulation where the distance was 100 inches. In a preliminary experiment at 50 inches, when the lamp was screened with the quartz-lite filter, there were no injurious effects and there was apparently a small amount of increased growth. At 100 inches, all rayed sets showed very definitely greater growth than the controls; in both plants, the greatest amount of increase occurred in the vita-glass constant-period group, set E; here, in the tomatoes, the plants at the end of the period showed an increase 33 per cent. greater than

[1] Eltinge, *Ann. Mo. Bot. Gard.*, 15: 169–240, 1928.
[2] Sheard and Higgins, SCIENCE, 65: 282–284, 1927.
[3] Popp and Brown, *Amer. Jour. Bot.*, 15: 623, 1928.
[4] Newell and Arthur, *Amer. Jour. Bot.*, 16: 338–354, 1929.

that of the controls; in the cucumbers, the percentage of increase over the controls was about 34 per cent. Dry weight percentages of wet weight and ash weight percentages of dry weight were greater in the rayed plants than in the controls, the former as much as 19 per cent. greater in the tomatoes, the latter as much as 13 per cent. greater. Numbers of leaves were greater in the rayed plants.

It is interesting to note that the incremental method induced greater increase in growth than did the constant period method, when the quartz-lite filter was used; with the unscreened arc, the injurious effects were considerably reduced by the former method of treatment. At 50 inches, in some cases, the constant period method seemed actually to retard growth slightly, even when the lamp was screened, whereas the incremental treatment caused the plants to grow somewhat more rapidly than did the controls. The reaction in the case of the incremental method seems to be of a two-fold nature: first, a gradual adjustment to the new environmental factor, then an increased growth rate under the influence of the gradually increasing intensity of that environmental stimulus.

This work was carried out under the direction of Dr. Ernest S. Reynolds. A detailed report is to be published later.

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HETEROTHALLISM IN PUCCINIA CORONATA

THE sporidium of *Puccinia coronata* Corda, on a Rhamnus leaf, germinates by forming a short beak, pierces the outer wall and enters the epidermal cell. The sporidial nucleus usually divides before entry. In the epidermal cell the fungus grows into a primary hypha of 4 to 6 cells, from each of which a branch forms which penetrates to the subepidermal region and develops there into haploid mycelium.

The mycelium spreads between the epidermis and the palisade, forcing the two layers apart and forming a continuous mat or stroma several cells thick. From this stroma hyphae grow down between the palisade cells into the spongy mesophyll. Haustoria may be unbranched or may fork dichotomously once, twice or even three times.

On the subepidermal stroma the pycnia form at fairly even intervals. Later a similar but smaller stroma forms next the lower epidermis and a few pycnia appear on it, which open onto the lower surface of the leaf. In old infections the whole upper stroma with its pycnia may peel off leaving the palisade layer exposed.

Puccinia coronata is at least partly, perhaps wholly, heterothallic. Eight Rhamnus plants bore 1 infection each. They were carefully isolated. Seven of the 8 remained sterile, that is, produced no aeciospores. On another plant bearing 6 infections the pycniospores were well mixed. Five of the 6 produced open aecia.

The sterile infection produces aecia which reach a considerable size but they form no spores. In these sterile aecia, however, there appear at a certain stage of development cells with 2 or 3 nuclei. These cells grow irregularly and their nuclei increase in number, but sooner or later they deteriorate and die. Multinucleate cells are to be found in practically 100 per cent. of all the older sterile aecia. A few of these multinucleate cells survive to a great age. In one sterile infection 62 days old there were living multinucleate cells of monstrous size, highly irregular in form and each containing 15 or 20 nuclei.

In the fertile infection the aecia produce spores regularly. Here are to be found an abundance of cells with 2 nuclei, some with 3, very rarely 1 with 4 or 5, but never the monstrous multinucleate cells so characteristic of sterile aecia.

The point at which the sporophyte is initiated in the fertile infection would seem to be variable. A few binucleate cells have been observed near a pycnium, in the subepidermal stroma, in hyphae between palisade cells, in the mycelium of the spongy mesophyll and above the aecium. Rarely a cell fusion can be seen between hyphal cells at some distance from an aecium. Cell fusions are most frequently found at or near the upper edge of the aecium, several cells above the sporogenous layer. In the majority of cases several cell divisions take place between the initial binucleate cell of a series and the basal cell which will produce the spores. Basal cells and spores are usually binucleate, rarely tri- or quadri-nucleate.

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